OFFICE OF ENVIRONMENTAL PROTECTION (OEP)
PRINCIPALITY OF LIECHTENSTEIN

Liechtenstein's Greenhouse Gas Inventory
1990 - 2010

National Inventory Report 2012

Submission of 13 April 2012
under the United Nations Framework Convention on Climate Change
and under the Kyoto Protocol

LIECHTENSTEIN

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Glossary

ARR	Annual Inventory Review Report (UNFCCC)
AD	Activity Data
ART	Agroscope Reckenholz-Tänikon Research Station
AZV	Abwasserzweckverband der Gemeinden Liechtensteins (Liechtenstein's wastewater administration union)
CH_4	Methane
CO	Carbon monoxide
CO_2, (CO_2 eq)	Carbon dioxide (equivalent)
CRF	Common reporting format
DOC	Degradable Organic Carbon
EF	Emission Factor
ERT	Expert Review Team
FAL	Swiss Federal Research Station for Agroecology and Agriculture (since 2006: ART)
FCCC	Framework Convention on Climate Change
FOD	First Order Decay Model
FOEN	Swiss Federal Office for the Environment (former name SAEFL)
Gg	Giga gramme (10^9 g = 1'000 tons = 1 kiloton)
GHFL	Genossenschaft für Heizöllagerung im Fürstentum Liechtenstein (Cooperative society for the Storage of Gas Oil in the Principality of Liechtenstein)
GHG	Greenhouse gas
GPG	Good Practice Guidance
GWP	Global Warming Potential
HFC	Hydrofluorocarbons (e.g. HFC-32 difluoromethane)
IDP	Inventory Development Plan
IEF	Implied Emission Factor
IPCC	Intergovernmental Panel on Climate Change
IR	Initial Report (UNFCCC)
KC	Key Category
KP	Kyoto Protocol
LFO	Light fuel oil (Gas oil)
LGV	Liechtensteinische Gasversorgung (Liechtenstein's gas utility)
LKW	Liechtensteinische Kraftwerke (Liechtenstein's electric power company)
LPG	Liquefied Petroleum Gas (Propane/Butane)
LULUCF	Land-Use, Land-Use Change and Forestry

MJ	Mega Joule (10^6 Joule = 1'00'000 Joule)
MSW	Municipal solid waste
MCF	Methan Conversion Factor
NCV	Net Calorific Value
NFR	Nomenclature for reporting (IPCC code of categories)
NIC	National Inventory Compiler
NIR	National Inventory Report
NIS	National Inventory System
NMVOC	Non-methane volatile organic compounds
N_2O	Nitrous oxide (laughing gas)
NO_x	Nitrogen oxides
OA	Office of Agriculture
OEA	Office of Economic Affairs
OEP	Office of Environmental Protection
OFIVA	Office of Food Inspection and Veterinary Affairs
OFNLM	Office of Forests, Nature and Land Management
OS	Office of Statistics
PFC	Perfluorinated carbon compounds (e.g. Tetrafluoromethane)
QA/QC	Quality assurance/quality control: QA includes a system of review procedures conducted by persons not directly involved in the inventory development process. QC is a system of routine technical activities to control the quality of the inventory.
SAEFL	Swiss Agency for the Environment, Forests and Landscape (former name of Federal Office for the Environment FOEN)
SF_6	Sulphur hexafluoride
SLP	Stabstelle für Landesplanung, Office of Land Use Planning
SO_2	Sulphur dioxide
TJ	Tera Joule (10^{12} Joule = 1'000'000 Mega Joule)
UNFCCC	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

ES.1 Background Information on Greenhouse Gas Inventories, Climate Change and Supplementary Information Required Under Art. 7.1. KP

ES.1.1 Background Information on Climate Change

According to research programs, significant negative effects of global climate warming in the Alpine region are to be expected. Changes in the permafrost layer and water drainages will play a central role in this regard.

The average temperature in Switzerland, Liechtenstein's neighboring country, has risen by 0.4°–0.6ºC per decade since 1970, in both summer and winter. These observations are expected to hold for Liechtenstein, too. This increase is up to three times as great as the worldwide increase and has been observed in the other Alpine countries as well. Between 1990 and 2050 the increase projected for northern Switzerland is +1.8 °C in winter and +2.7 °C in summer. Further increases of +10% in the winter half-year and reductions of -20% in the summer half-year compared to 1990 levels are being predicted, which would represent a substantial shift in the seasonal distribution of precipitation. Glaciers in the Alps have lost 25% of their volume since 1970. Phenological observations show that the biological beginning of spring has been advancing by 1.5–2.5 days per decade.

The following effects can be expected as a consequence of a further rise in temperature and reduction of permafrost: Heat waves with increased mortality will occur more frequently, also tropical diseases will surface in Central Europe and existing diseases will spread to higher elevations. Indirect consequences for health are to be expected from storm, floods, and landslides. The increasing weather instabilities may lead to floods in winter and droughts in summer time and composition of forest vegetation may change too. Global climate warming will therefore affect various economic sectors in Liechtenstein (e.g. Tourism, Agriculture).

ES.1.2 Background Information on Greenhouse Gas Inventories

In 1995, the Principality of Liechtenstein ratified the United Nations Framework Convention on Climate Change (UNFCCC). Furthermore in 2004, Liechtenstein ratified the Kyoto Protocol to the UNFCCC. A National Inventory System (NIS) according to Article 5.1 of the Kyoto Protocol has been implemented.

In 1995, 2001, 2005 and 2010 Liechtenstein submitted its National Communication Reports to the secretariat of the UNFCCC. Also, a first Greenhouse Gas Inventory (without National Inventory Report) was submitted in the Common Reporting Format (CRF) in 2005. In 2006, two submissions took place, the first on 31 May including the national greenhouse gas inventory for 1990 and 2004 as well as the National Inventory Report (NIR). The second submission on 22 December 2006 contained the national greenhouse gas inventory for the whole time period 1990–2004, National Inventory Report and the Initial Report under Article 7, paragraph 4 of the Kyoto Protocol (OEP 2006, 2006a, 2007a). In May 2007 the GHG inventory 1990–2005 was submitted together with the National Inventory Report (OEP 2007). In February 2008, in April 2009, 2010 and 2011, the further GHG inventories 1990–2006, 1990-2007, 1990-2008 and 1990-2009 were submitted together with the National Inventory Report (OEP 2008, OEP 2009a, OEP 2010b, OEP 2011a). The present report is Liechtenstein's seventh National Inventory Report, NIR 2012, prepared under the UNFCCC and under the Kyoto Protocol. It includes, as a separate document, Liechtenstein's 1990–2010 Inventory in the CRF. Furthermore, the Standard Electronic Format application (SEF) is submitted along with the NIR 2012, providing an annual account of Kyoto units traded in the respective year.

From 11 to 15 June 2007 an individual review (In-Country Review) took place in Vaduz: The submission documents, the Initial Report and the GHG inventory 1990-2004 including CRF tables and National Inventory Report were objects of the review. Following the recommendations of the expert review team, some minor corrections were carried out in the emission modelling leading to recalculations and some methodological changes (revision of the definition of forests). Due to the recalculation, the time series of the national total of emissions did slightly change and therefore, Liechtenstein's assigned amount has been adjusted by -0.407%. After this correction, Liechtenstein's assigned amount is 1055.623 Gg CO_2 equivalents.

In September 2008, 2009, 2010 and 2011 centralized reviews of Liechtenstein's GHG inventories and NIRs of 2007/2008, 2009, 2010 and 2011 took place in Bonn, Germany. Again a number of recommendations were addressed to Liechtenstein, which were accounted for in the subsequent submissions (FCCC/ARR 2009,2010,2010a; the ARR 2011 will soon be available).

The Office of Environmental Protection (OEP) is in charge of compiling the emission data and bears overall responsibility for Liechtenstein's national greenhouse gas inventory. All inventory data are assembled and prepared for input by an inventory group. It is responsible for ensuring the conformity of the inventory with UNFCCC guidelines. In addition to the OEP, the Office of Economic Affairs (OEA), the Office of Agriculture (OA), the Office of Forests, Nature and Land Management (OFNLM) and the Office of Land Use Planning (SLP) participate directly in the compilation of the inventory. Several other administrative and private institutions are involved in inventory preparation.

The emissions are calculated based on the standard methods and procedures of the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC 1997a, 1997b, 1997c) and IPCC Good Practice Guidances (IPCC 2000, IPCC 2003) as adopted by the UNFCCC. The activity data sources used to compile the national inventory and to estimate greenhouse gas emissions and removals are: The national energy statistics, separate statistics for the consumption of gasoline and diesel oil, agriculture, LULUCF and waste. The data is compiled and set up in line with the FCCC inventory guidelines (FCCC 2003). The data is finally implemented in the CRF Reporter that generates the **CRF tables**.

The **National Inventory Report** follows in its structure the default chapters of the UNFCCC Guidelines on Reporting of Greenhouse Gas Inventories (FCCC 2002) and the "Annotated outline of the National Inventory Report including reporting elements under the Kyoto Protocol" (FCCC 2006).

For the interpretation of the Liechtenstein's emissions and removals it is important to recognise that Liechtenstein is a small central European State in the Alpine region with a population of 36'149 inhabitants (as of 31 December 2010) and with an area of 160 km^2. Its neighbours are therefore important partners: Liechtenstein and Switzerland form a customs and monetary union governed by a customs treaty. On the basis of this union, Liechtenstein is linked to Swiss foreign trade strategies, with few exceptions, such as trade with the European Economic Community: Liechtenstein – contrary to Switzerland – is a member of the European Economic Area. The Customs Union Treaty with Switzerland impacts greatly on environmental and fiscal strategies. Many Swiss levies and regulations for special goods (for example, environmental standards) are also adapted and applied in Liechtenstein. For the determination of the GHG emissions, Liechtenstein appreciates having been authorised to adopt a number of Swiss methods and Swiss emission factors.

ES.1.3 Background Information on Supplementary Information Required under Article 7.1. KP

According to paragraph 25 of the annex to decision 13/CMP.1, Liechtenstein had to determine for each activity of the LULUCF sector whether removal units (RMUs) shall be issued annually or for the entire commitment period. Liechtenstein has chosen to account annually for emissions and removals from the LULUCF sector [see Chapter 7 of the Initial Report (OEP 2006a).The decision remains fixed for the entire first commitment period.

Liechtenstein has elected to not account for LULUCF activities under Article 3.4 during the first commitment period, as stated in its Initial Report (OEP 2006a, p.22).

For forest, Liechtenstein has chosen the following definition (OEP 2007b):

- minimum area of land: 0.0625 hectares (with a minimum width of 25 m)
- minimum crown cover: 20 per cent
- minimum height of the dominant trees: 3 m (dominant trees must have the potential to reach 3 m at maturity in situ)

ES.2 Summary of National Emission and Removal Related Trends, and Emission and Removals from KP-LULUCF Activities

ES.2.1 GHG Inventory

In 2010, Liechtenstein emitted 233.2 Gg CO_2 equivalent, or 6.63 tonnes CO_2 equivalent per capita (CO_2 only: 5.66 tonnes per capita) to the atmosphere excluding LULUCF.

From 1990 until 2010 the national total emissions excluding LULUCF increased by 1.9%. If the total includes the emissions from LULUCF, the increase is 3.0%.

Uncertainties: An uncertainty analysis (Tier 1) is carried out and presented in Chapter 1.7.1.3. It estimates the level uncertainty of total CO_2 emissions including LULUCF sector in 2010of 7.20% (level uncertainty) and the trend uncertainty 1990-2010 of 7.48%.

Recalculations: Some emissions have been recalculated due to updates in several sectors. The results are discussed in Chapter 10. For the base year there is a slight decrease of 0.003% in the national total emissions excluding LULUCF. If emissions and removals from LULUCF are included, the decrease of the national total compared to 2009 is also 0.003% .

ES.2.2 KP-LULUCF Activities

Liechtenstein reports the mandatory LULUCF activities Afforestation and Deforestation (Reforestation is not occurring in Liechtenstein) under Article 3, paragraph 3 of the Kyoto Protocol. ES Table 1-1 shows the result for the second KP-LULUCF Inventory year 2010. Afforestation and deforestation resulted in a net removal of -3.11 Gg CO_2 in 2010.

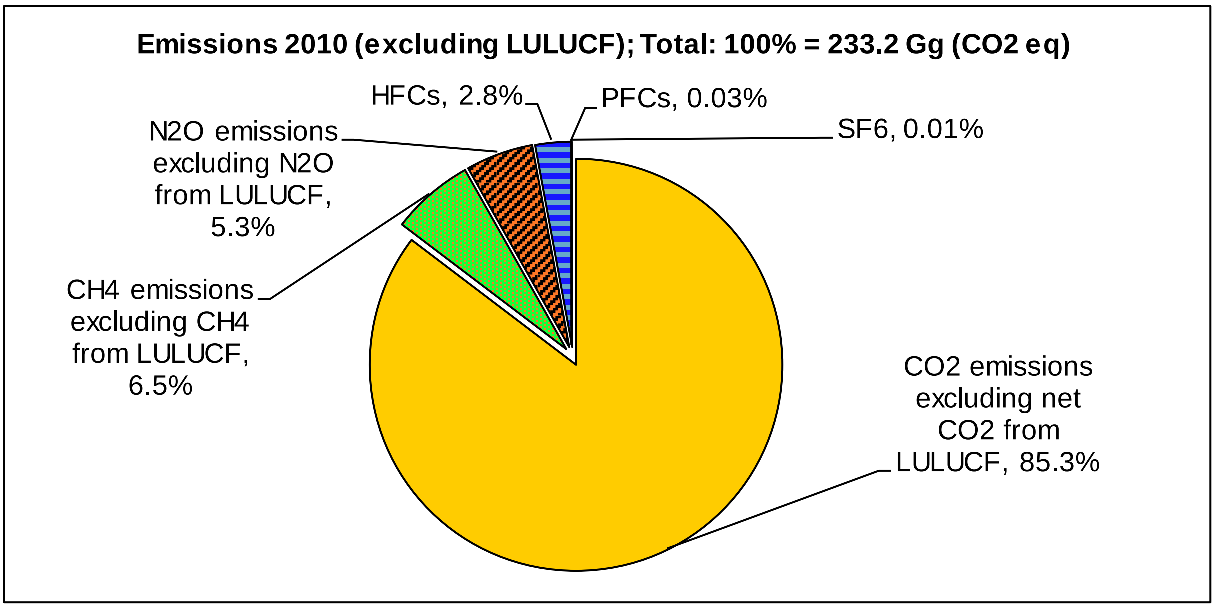
ES Table 1-1: Summary table afforestation and deforestation. Numbers are taken from Table KP(5-I)A.1.1. and KP(5-I)A.2.

Activity	**Area** (cumulated 1990-2010) kha	**Net CO_2 emisson/removal** 2010 Gg CO_2
Afforestation	0.61	-3.26
Deforestation	0.02	0.14
Total net CO_2 emission/removal		**-3.11**

ES.3. Overview of Source and Sink Category Estimates and Trends, including KP-LULUCF Activities

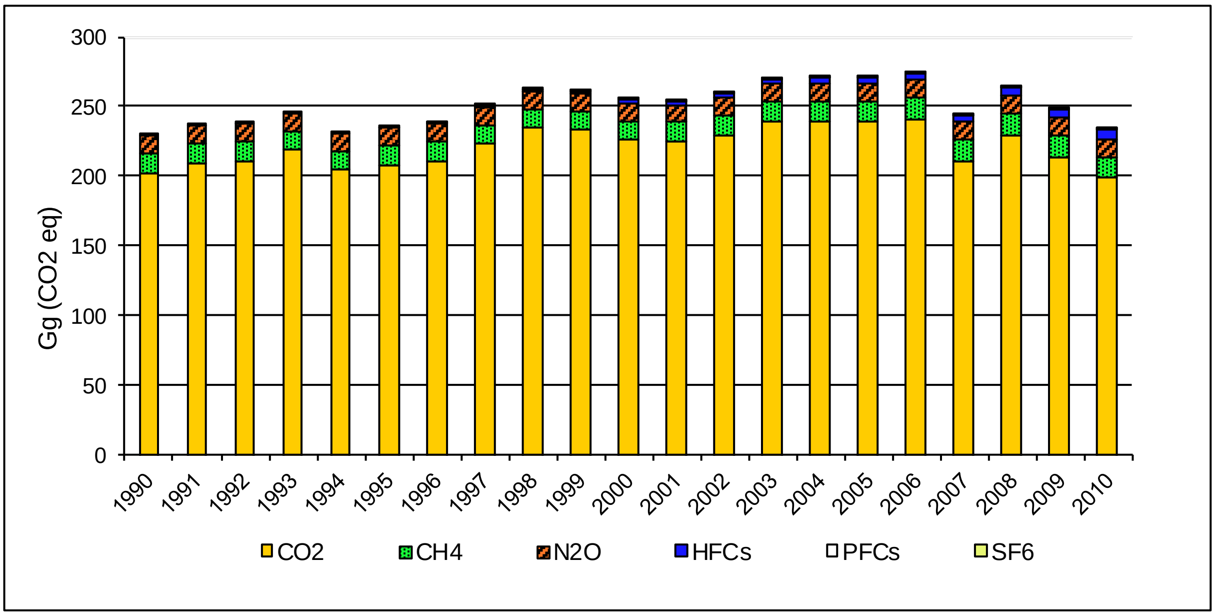
ES.3.1 GHG Inventory

ES Figure 1-1 shows the emissions in 2010 by gases. The main GHG is CO_2 with a share of 86.6%. CH_4 and N_2O contribute with 5.9% and 5.3%, synthetic gases with 2.3%.



ES Figure 1-1 Liechtenstein's GHG emissions by gas (excluding LULUCF) in 2010.

ES Figure 1-2 shows that the 2010 shares are typical for the period 1990-2010. After increasing emissions between 1990 and 1998, the emissions fluctuate between 1998 and 2006 on a relative constant level. Due to warm winter times and high fuel prices, the consumption decreased in 2007. In 2008 it reached a higher level again and then decreased in 2009 and subsequent in 2010, indicating a negative emissions trend since 2006.



ES Figure 1-2 Trend of Liechtenstein's greenhouse gas emissions by gases1990–2010. CO_2, CH_4 and N_2O correspond to the respective total emissions excluding LULUCF.

Over the period 1990-2010, the share of CO_2 fluctuated between 85.3% (2010) and 89.52% (1999). The share of CH_4 increased slightly with 5.8% in 1990 and 6.5% in 2010.

Simultaneously, the share of N_2O decreased from 5.7% to 5.3% whereas the share of synthetic gases increased from 0.0% (1990) to 2.8% (2010).

ES Table 1-2 Summary of Liechtenstein's GHG emissions in CO_2 equivalent (Gg) by gas, 1990–2010. The column on the far right (digits in italics) shows the percent change in emissions in 2010 as compared to the base year 1990.

Greenhouse Gas Emissions	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	193.4	201.2	202.1	210.5	196.6	200.0	202.2	219.5	230.9	230.1
CO_2 emissions excluding net CO_2 from LULUCF	201.6	209.4	210.4	218.8	205.0	208.4	210.6	223.0	234.4	233.5
CH_4 emissions including CH_4 from LULUCF	14.4	14.3	14.0	13.4	13.5	13.4	13.8	13.6	13.5	13.1
CH_4 emissions excluding CH_4 from LULUCF	14.4	14.3	14.0	13.4	13.5	13.4	13.8	13.6	13.5	13.1
N_2O emissions including N_2O from LULUCF	12.9	13.3	13.2	12.8	12.8	12.8	12.9	12.8	12.7	12.6
N_2O emissions excluding N_2O from LULUCF	12.9	13.3	13.2	12.8	12.8	12.8	12.8	12.7	12.6	12.4
HFCs	0.0	0.0	0.0	0.1	0.1	0.4	0.7	1.0	1.4	1.8
PFCs	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0	0.0
SF_6	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0	0.0	0.0	0.0
Total (including LULUCF)	**220.7**	**228.7**	**229.3**	**236.8**	**223.0**	**226.6**	**229.6**	**246.9**	**258.5**	**257.6**
Total (excluding LULUCF)	**228.9**	**237.0**	**237.6**	**245.1**	**231.4**	**235.0**	**237.9**	**250.3**	**261.9**	**260.9**

Greenhouse Gas Emissions	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	***1990-2010***
	CO_2 equivalent (Gg)											*%*
CO_2 emissions including net CO_2 from LULUCF	223.4	221.5	226.5	233.4	233.6	233.4	235.0	204.3	223.3	207.7	193.0	*-0.2*
CO_2 emissions excluding net CO_2 from LULUCF	226.8	224.9	229.9	239.4	239.6	239.4	241.1	210.4	229.4	213.7	199.0	*-1.3*
CH_4 emissions including CH_4 from LULUCF	13.0	13.6	13.9	14.0	14.1	14.7	15.2	15.6	15.8	15.6	15.1	*5.1*
CH_4 emissions excluding CH_4 from LULUCF	13.0	13.6	13.9	14.0	14.1	14.7	15.2	15.6	15.8	15.6	15.1	*5.1*
N_2O emissions including N_2O from LULUCF	12.4	12.5	12.5	12.5	12.2	12.4	12.6	12.7	12.7	12.6	12.3	*-4.2*
N_2O emissions excluding N_2O from LULUCF	12.2	12.5	12.5	12.5	12.2	12.4	12.5	12.7	12.7	12.6	12.3	*-4.2*
HFCs	2.3	3.0	3.3	3.8	4.3	4.4	4.4	4.7	5.1	5.3	6.6	---
PFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	---
SF_6	0.1	0.2	0.3	0.3	0.3	0.3	0.1	0.1	0.4	0.1	0.0	---
Total (including LULUCF)	**251.2**	**250.8**	**256.4**	**264.0**	**264.6**	**265.1**	**267.3**	**237.4**	**257.3**	**241.3**	**227.2**	***3.0***
Total (excluding LULUCF)	**254.5**	**254.2**	**259.8**	**270.0**	**270.6**	**271.1**	**273.3**	**243.5**	**263.5**	**247.3**	**233.2**	***1.9***

ES Table 1-3 shows the GHG emissions and removals by categories. The energy sector is the largest source of national emissions, contributing to 86.5% of the emissions (excluding LULUCF). A slight decrease of -1.1% is found for the energy sector for the period 1990–2010. The emissions from industrial processes exclusively consist of synthetic gases, which have increased since 1990, whereas emissions from Solvent and other Product Use have decreased by -5.0%. The emissions from agriculture showed a slight decrease from 1990–2000 followed by a slight increase. In 2010 the emissions were -1.8% under the level of 1990. Emissions and removals in the LULUCF sector form a net sink with net removals in the range between -3.2 to -8.4 Gg CO_2 eq. The emissions from the waste sector have increased by 8.5%, but notably it encompasses only a small amount of emissions - mainly from composting – because municipal solid waste is exported to a Swiss incineration plant.

ES Table 1-3 Summary of Liechtenstein's GHG emissions by source and sink categories in CO_2 equivalent (Gg), 1990–2010. The column on the far right (digits in italics) shows the percent change in emissions in 2010 as compared to the base year 1990.

Source and Sink Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
1 Energy	**203.8**	**211.8**	**212.9**	**221.3**	**207.4**	**210.9**	**213.2**	**225.7**	**237.0**	**236.3**
1A1 Energy Industries	0.2	0.8	1.9	1.9	1.8	2.0	2.5	2.5	2.9	2.9
1A2 Manufacturing Industries and Construction	35.3	34.2	34.2	36.0	34.2	34.4	34.3	35.9	38.2	37.6
1A3 Transport	76.7	90.0	89.3	87.2	79.8	81.8	83.1	86.8	86.4	92.1
1A4 Other Sectors	88.9	83.4	84.2	93.3	88.8	89.9	90.3	97.4	105.9	99.8
1A5 Other (Offroad)	2.4	2.9	3.0	2.4	2.3	2.2	2.3	2.6	3.0	3.1
1B Fugitive emissions from oil and natural gas	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7
2 Industrial Processes	**0.0**	**0.0**	**0.0**	**0.1**	**0.1**	**0.4**	**0.7**	**1.0**	**1.4**	**1.8**
3 Solvent and Other Product Use	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.5**	**0.5**	**0.5**
4 Agriculture	**23.0**	**23.1**	**22.6**	**21.6**	**21.7**	**21.6**	**21.9**	**21.5**	**21.3**	**20.6**
6 Waste	**1.6**	**1.5**	**1.5**	**1.5**	**1.6**	**1.5**	**1.6**	**1.6**	**1.6**	**1.6**
Total (excluding LULUCF)	**228.9**	**237.0**	**237.6**	**245.1**	**231.4**	**235.0**	**237.9**	**250.3**	**261.9**	**260.9**
5 Land Use, Land-Use Change and Forestry	-8.2	-8.3	-8.3	-8.3	-8.4	-8.4	-8.4	-3.4	-3.4	-3.2
Total (including LULUCF)	220.7	228.7	229.3	236.8	223.0	226.6	229.6	246.9	258.5	257.6

Source and Sink Categories	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	*1990-2010*
	CO_2 equivalent (Gg)											*%*
1 Energy	**229.7**	**227.6**	**232.5**	**242.0**	**242.0**	**241.9**	**243.6**	**213.0**	**232.0**	**216.3**	**201.6**	***-1.1***
1A1 Energy Industries	2.7	2.9	2.5	2.8	2.9	3.1	2.8	2.5	2.9	2.9	3.2	*1727.1*
1A2 Manufacturing Industries and Construction	34.3	34.6	35.7	38.3	37.4	36.2	37.4	30.9	33.0	23.8	22.4	*-36.6*
1A3 Transport	96.1	92.4	87.8	87.4	85.9	85.4	82.4	86.5	90.9	84.8	80.3	*4.7*
1A4 Other Sectors	92.8	94.4	103.0	109.3	111.9	112.7	116.2	88.6	100.5	100.1	91.2	*2.6*
1A5 Other (Offroad)	3.0	2.6	2.8	3.5	3.1	3.5	3.7	3.4	3.6	3.7	3.5	*46.7*
1B Fugitive emissions from oil and natural gas	0.7	0.8	0.8	0.9	0.9	1.0	1.1	1.1	1.1	1.0	1.1	*230.9*
2 Industrial Processes	**2.4**	**3.2**	**3.5**	**4.0**	**4.6**	**4.7**	**4.5**	**4.8**	**5.5**	**5.5**	**6.7**	**---**
3 Solvent and Other Product Use	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	***-5.0***
4 Agriculture	**20.1**	**21.3**	**21.5**	**21.6**	**21.7**	**22.1**	**23.0**	**23.3**	**23.4**	**23.2**	**22.6**	***-1.8***
6 Waste	**1.7**	**1.6**	**1.7**	**1.8**	**1.8**	**1.9**	**1.8**	**1.9**	**2.0**	**1.8**	**1.7**	***8.5***
Total (excluding LULUCF)	**254.5**	**254.2**	**259.8**	**270.0**	**270.6**	**271.1**	**273.3**	**243.5**	**263.5**	**247.3**	**233.2**	***1.9***
5 Land Use, Land-Use Change and Forestry	-3.2	-3.4	-3.4	-6.0	-6.0	-6.0	-6.1	-6.1	-6.1	-6.0	-6.0	*-27.0*
Total (including LULUCF)	**251.2**	**250.8**	**256.4**	**264.0**	**264.6**	**265.1**	**267.3**	**237.4**	**257.3**	**241.3**	**227.2**	***3.0***

KCA:
In 2010, 15 categories were identified as key categories in level and trend analysis for Liechtenstein, covering 95.2% of total greenhouse gas (GHG) emissions (CO_2 equivalent). There are five major key sources which contribute together 66.4% of the key sources:

- 1A3b Energy, Fuel Combustion, Road Transportation, gasoline: CO_2, level contribution 19.9%,
- 1A4a Energy, Fuel Combustion, Other Sectors, Commercial/Institutional, liquid fuels: CO_2, level contribution 13.3%.
- 1A3b Energy, Fuel Combustion, Road Transportation, diesel: CO_2, level contribution 12.7%,
- 1A4b Energy, Fuel Combustion, Other Sectors, Residential, gaseous fuels: CO_2, level contribution 11.3%.
- 1A4a Energy, Fuel Combustion, Other Sectors, Commercial/Institutional, gaseous fuels: CO_2, level contribution 9.1%.

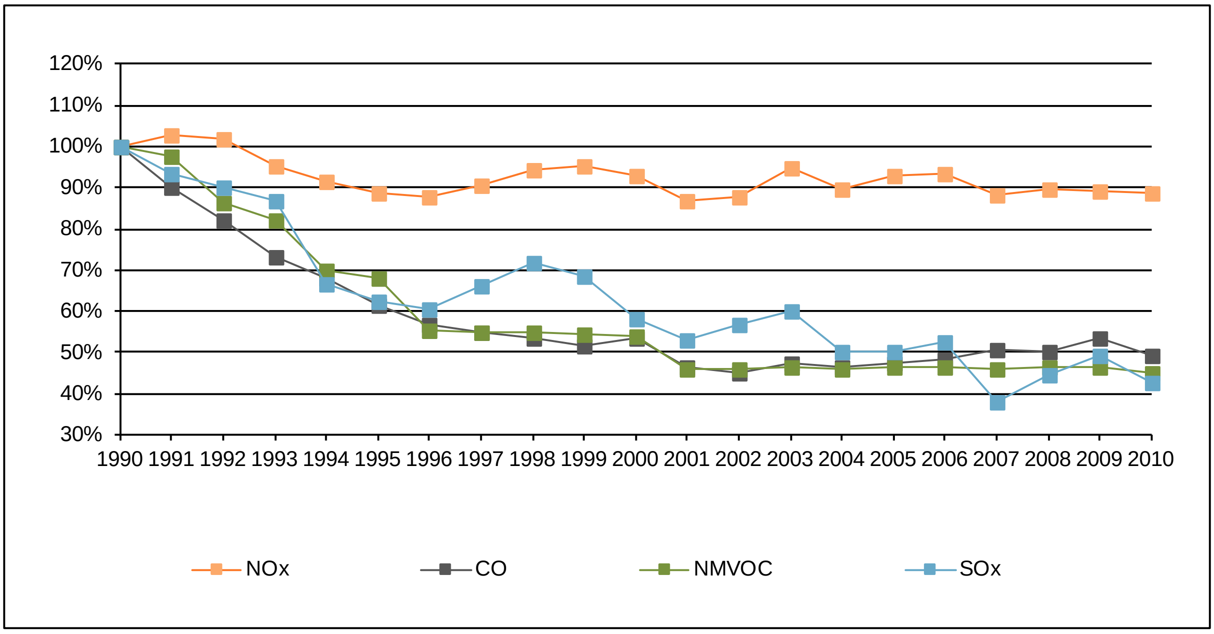
In the KCA 2010 including LULUCF categories there are in total 137 categories. 19 of them are key categories. Four of the key categories are from the LULUCF sector. The largest category is 5A1 Forest Land remaining Forest Land; the other LULUCF key categories are of minor importance.

ES.3.2 KP-LULUCF Activities

See ES 2.2 for KP-LULUCF overview.

ES.4. Other Information

Liechtenstein is member to the Geneva Convention on Long-range Transboundary Air Pollution (CLRTAP) and submits emission data on indirect Greenhouse Gases. For the precursor substances NO_x, CO and NMVOC as well as for the gas SO_2, data from the UNECE – CLRTAP submission is used. Note that the system boundaries for the transportation sector are not the same as under the UNFCCC Reporting since the CLRTAP uses the territorial principle, which restricts the comparability of the two data sets.



ES Figure 1-3 Trend of emissions of NOx, CO, NMVOC and SO_2 1990-2010

Acknowledgement

Liechtenstein's Office of Environmental Protection (OEP) highly appreciates the generous support by the members of the GHG Inventory Core Group at the Swiss Federal Office for Environment (FOEN). The free use of methods and tools developed by the FOEN has been essential during the development of the completely revised Liechtenstein GHG inventory and the NIR.

The OEP also gratefully acknowledges the support of the Agroscope Reckenholz-Tänikon Research Station (ART). The use of the worksheet developed by ART greatly facilitated the modelling of agricultural emissions and their uncertainties. Personal and close contacts between the GHG specialists of Switzerland and Liechtenstein developed during this work which laid the basis for a very promising and fruitful cooperation both on a technical and on a political level.

The OEP also thanks the data suppliers of Liechtenstein: Office of Agriculture, Office of Economic Affairs, Office of Statistics, Office of Forests, Nature and Land Management, Office of Land Use Planning, Liechtensteinische Gasversorgung, Liechtensteinische Kraftwerke, Abwasserzweckverband der Gemeinden Liechtensteins (AZV), Rhein Helikopter AG, the sectoral experts and the NIR authors. Their effort made it possible to finalise the inventory and the NIR in due time.

PART 1
Annual Inventory Submission

1 Introduction

1.1 Background Information on Liechtenstein's Greenhouse Gas Inventory, Climate Change and Supplementary Information of the KP

1.1.1 Background Information on Climate Change

In recent years, various research programs on the effects of global climate warming in the Alpine region have been conducted. The development so far and projections indicate that noticeable effects are to be expected. Changes to the permafrost line and water drainages will play a central role in this regard. Liechtenstein is also affected by these developments.

The expected impacts of climate change have primarily been studied in Switzerland, which is one of the two neighbouring countries of Liechtenstein, and draw to a large extent on the findings of a report prepared by the Swiss Advisory Body on Climate Change (OcCC 2007), which documents the present state of knowledge. Also results of a report of the international bodensee conference have been considered with specific findings for Liechtenstein (IBK 2007).

Impacts

The mean annual temperature of Liechtenstein currently lies at 10.3°C (1980 – 2009). The mean annual temperature has increased from 8.6 °C in 1980 to 10.8 °C in 2009. Mean temperature projections for the years 2030, 2050 and 2070 have been calculated (Frei 2004). The results for winter and summer are graphically shown in Figure 1-1 together with observed temperature anomalies from 1864 to 2008. According to the mean estimate temperatures between 1990 and 2050 will increase in Liechtenstein and northern Switzerland by 1.8 °C in winter and 2.7°C in summer.

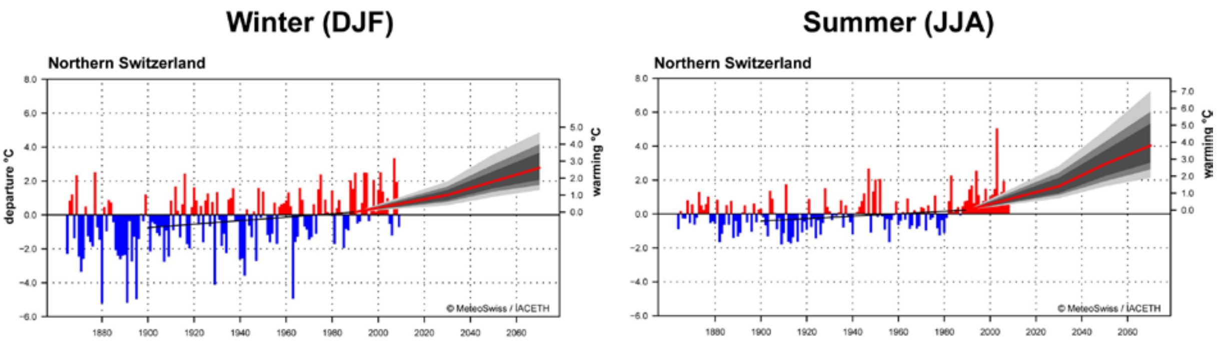


Figure 1-1 Observed temperature anomalies and projected changes in mean temperature (Frei 2004)

The trends in precipitation are less distinct than in temperature. For a number of stations a significant increase in precipitation is found in winter and spring (+2.7 to +3.1% per decade). For summer and autumn no significant trends are detectable. Until the middle of the 21st century, an increase of 8% is expected in winter and a decrease of 17% in summer (Frei 2004, IBK 2007).

The warming trend and changing precipitation patterns are also expected to have significant effects on ecosystems. The Biodiversity Monitoring Switzerland reports that impacts of climate change are being observed even within limited time frames. For instance, typical alpine vascular plants have shifted their distribution in the uphill direction during the past few years and phenological observations show that the biological beginning of spring has been advancing by 1.5 – 2.5 days per decade.

The expected increased intensity of storms and reduced snowfall and snow cover duration are particularly important for alpine areas, tourism and forestry due to more frequent floods, landslides and debris flows and an increase of threats by avalanches.

Vulnerability assessments

It is difficult to transfer the consequences of global climate warming calculated on the basis of models to the spatial scale of Liechtenstein (some 10 km). The available climate models are not yet able to predict detailed regional consequences. Overall, however, the following general effects can be expected as a consequence of a further increase of the CO_2 concentration and the associated rise in temperature.

Health: The increase in intensity of heat waves in combination with high tropospheric ozone concentrations represents the greatest risk that climate change poses to people’s health. Another important risk of climate change for health is the occurrence of vector-borne diseases. There is still predominant uncertainty about what future developments will be considering further health issues.

Ecosystems: Warming changes the composition of forest vegetation. Deciduous trees may become more important than today. Additional weather instabilities (e.g., storms, avalanches) may have a further negative effect on forest vegetation.

Water cycles and soil: The increasing weather instabilities may lead to floods in winter and droughts in summer time. A great danger in this regard exists in the narrow Alpine valleys (mountain streams), where various protective measures (e.g., rock fall barriers and water course corrections) are necessary. A further danger is posed by the Rhine: Although regulated, the river may endanger the intensively used valley floor in the event of a flood.

Tourism: Within the next decades Liechtenstein’s tourism sector will have to deal with great challenges caused by climate change related developments in Liechtenstein’s ecosystems. Especially the winter tourism sector will be hit by higher temperature as the rise of the freezing level will lead to higher snow lines.

Other economic sectors: Global climate warming will affect further economic sectors in Liechtenstein. Because of the processes described above, agriculture and forestry will be affected directly. A rise in temperature will have a negative effect on the productivity of grain cultivation in the long term. The expected increase in elevation of the snow boundaries and increasing weather instability also have an effect on the important recreation area of Malbun and Steg. The international engagement of the insurance sector will likely suffer the most severe negative consequences from an increase in the probability of losses.

Adaptation/ Mitigation

The projected consequences of an ongoing climate change require the immediate implementation of the so called Two-Pillar-Strategy – Mitigation (Pillar1) and Adaptation (Pillar 2).

Mitigation: The necessary reduction of greenhouse gases can only be achieved if concrete measures are implemented in due time. Liechtenstein has launched a set of measures to address the problem of growing greenhouse gas emissions such as the Energyconcept 2013 (OEA, 2003) / Energyconcept 2020 (in preparation), Emissions Trading Act (OEP, 2008b), Energy Efficiency Act (OEA, 2008), CO_2 -Act (OEP, 2008c), Environmental Protection Act (OEP, 2008d), National Transport Policies, National Climate Protection Strategy (OEP, 2007d) and Action Plan Air (OEP, 2007e). Liechtenstein’s climate policy goal is – in the midterm – to fulfill the obligations originating from the Kyoto Protocol. The mitigation measures however will be further developed, especially with respect to sectors that have not yet been totally included into strict climate change regulation (e.g. traffic and transportation).

Adaptation: It is already obvious that certain climate change related consequences will become irreversible. Pillar 2 deals with the question of how these future threats could be addressed and how potential future damages can be limited or even avoided.

Natural hazard: Liechtenstein has established so called “Geological Risk Maps” with a special focus on residential areas. These maps provide regional information on the specific risks regarding avalanches, rock- and landslides and flooding.

Agriculture: Identified adaptation measures are an increased use of appropriate corn provenances, that have already anticipated future conditions of the changing environment. However, the use of genetically modified crops is not foreseen. The irrigation of agricultural fields will increasingly be used thereby causing conflicts with other public interests, especially during longer draught periods.

Forestry: The increase of draught periods with consequential damages caused by insects, pathogens (viruses, bacteria, fungus) fire or storms will lead to a decrease of the forests protection abilities in Liechtenstein. Adaptation measures that address the problems of these projected situations and that are already executed are the conversion of spruce and fir stocks into mixed deciduous and coniferous forests.

Tourism: Further efforts have to be steped up within the next years. The production of artificial snow, as currently practiced, is not considered to be a sustainable solution. Nevertheless, various municipalities and institutions have introduced new offerings for winter and summer tourism, in order to counter potential revenue losses. The focus is on strategies to promote "gentle tourism".

1.1.2 Background Information on Greenhouse Gas Inventory

In 1995, the Principality of Liechtenstein ratified the United Nations Framework Convention on Climate Change (UNFCCC). Furthermore in 2004, Liechtenstein ratified the Kyoto Protocol to the UNFCCC. A National Inventory System (NIS) according to Article 5.1 of the Kyoto Protocol has been implemented.

In 1995, 2001, 2005 and 2010, Liechtenstein submitted its National Communication Reports to the secretariat of the UNFCCC. Greenhouse Gas Inventories and National Inventory Reports were submitted in the following years:

- 2005: The first Greenhouse Gas Inventory of Liechtenstein was submitted in the Common Reporting Format (CRF) without National Inventory Report.
- 2006: The first submission took place on 31 May including the national greenhouse gas inventory for 1990 and 2004 as well as the National Inventory Report. A re-submission on 22 December 2006 contained the national greenhouse gas inventory for the whole time period 1990–2004, the National Inventory Report 2006 (OEP 2006) and the Initial Report under Article 7, paragraph 4 of the Kyoto Protocol including a Corrigendum (OEP 2006a, 2007b).
- 2007: Submission of the Greenhouse Gas Inventory 1990–2005 together with the National Inventory Report 2007 on 10 May 2007 (OEP 2007).
- 2008: Submission of the Greenhouse Gas Inventory 1990–2006 together with the National Inventory Report 2008 prepared under the UNFCCC and under the Kyoto Protocol on 29 February 2008 (OEP 2008).
- 2009: Submission of the Greenhouse Gas Inventory 1990–2007 together with the National Inventory Report 2009 prepared under the UNFCCC and under the Kyoto Protocol on 29 February 2009 (OEP 2009a). Furthermore, the Standard Electronic Format application (SEF) was submitted.

- 2010: Submission of the Greenhouse Gas Inventory 1990–2008 together with the National Inventory Report 2010 prepared under the UNFCCC and under the Kyoto Protocol on 11 March 2010 (OEP 2010b). Additionally, the Standard Electronic Format application (SEF) was submitted. Submission 2010 incorporated the new guidelines: Annotated outline of the National Inventory Report including reporting elements under the Kyoto Protocol (IPPC 2009).
- 2011: Submission of the Greenhouse Gas Inventory 1990–2009 together with the National Inventory Report 2011 prepared under the UNFCCC and under the Kyoto Protocol on 11 March 2011 (OEP 2011a). Additionally, the Standard Electronic Format application (SEF) was submitted.
- The present report is Liechtenstein's 8th National Inventory Report, NIR 2012, prepared under the UNFCCC and under the Kyoto Protocol. The present report includes, as a separate files, Liechtenstein's 1990–2010 Inventory in the CRF Reporter format and the updated Standard Electronic Format application (SEF).

From 11 to 15 June 2007 an individual review (In-Country Review) took place in Vaduz: The submission documents, the Initial Report and the GHG inventory 1990-2004 including CRF tables and National Inventory Report were objects of the review. Following the recommendations of the expert review team, some minor corrections were carried out in the emission modelling leading to recalculations and some methodological changes (revision of the definition of forests). The consequences are documented in the reports of the review of the initial report of Liechtenstein (FCCC/IRR 2007) and of the individual review of the greenhouse gas inventory of Liechtenstein submitted in 2006 (FCCC/ARR 2007). Due to the recalculation, the time series of the national total of emissions slightly changed and therefore, Liechtenstein's assigned amount has been adjusted by -0.407%. The modifications are documented in a Response by Party and a Corrigendum to the Initial Report (OEP 2007a, 2007b). In September 2008 a centralized review of Liechtenstein's GHG inventories and NIRs of 2007 and 2008 took place in Bonn, Germany with results documented in FCCC/ARR 2009. Further centralized reviews took place in September 2009 (inventory and NIR of 2009, FCCC/ARR 2010), in September 2010 (inventory and NIR 2010, FCCC/ARR 2010a) and in September 2011 (inventory 1990–2009 and NIR 2011.)

1.1.3 Background Information on Supplementary Information Required under Art. 7.1. KP

According to paragraph 25 of the annex to decision 13/CMP.1, Liechtenstein had to determine for each activity of the LULUCF sector whether removal units (RMUs) shall be issued annually or for the entire commitment period. Liechtenstein has chosen to account annually for emissions and removals from the LULUCF sector (see Chapter 7 of the Initial Report, OEP 2006a).The decision remains fixed for the entire first commitment period.

Liechtenstein has elected to not account for LULUCF activities under Article 3.4 during the first commitment period, as stated in its Initial Report (OEP 2006a, p.22).

1.2 Institutional Arrangements for Inventory Preparation, including the Legal and Procedural Arrangements for Inventory Planning, Preparation and Management

1.2.1 Overview of Institutional, Legal and Procedural Arrangements for Compiling GHG Inventory and Supplementary Information for KP

The Office of Environmental Protection (OEP) is in charge of compiling the emission data and bears overall responsibility for Liechtenstein's national greenhouse gas inventory. In addition to the OEP, the Office of Economic Affairs (OEA), the Office of Agriculture (OA), the Office of Forests, Nature and Land Management (OFNLM) and the Office of Land Use Planning (SLP) participate directly in the compilation of the inventory. Several other administrative and private institutions are involved in inventory preparation.

Liechtenstein is a small central European State in the Alpine region with a population of 36'149 inhabitants (as of 31 December 2010) and with an area of 160 km^2. Liechtenstein and its neighbouring country Switzerland form a customs and monetary union governed by a customs treaty (Government, 1980). On the basis of this union, Liechtenstein is linked to Swiss foreign trade strategies, with few exceptions, such as trade with the European Economic Community: Liechtenstein – contrary to Switzerland – is a member of the European Economic Area. The Customs Union Treaty with Switzerland impacts greatly on environmental and fiscal strategies. Many Swiss levies and regulations for special goods, for example, environmental standards for motor vehicles and quality standards for fuels are also adapted and applied in Liechtenstein. For the determination of the GHG emissions, Liechtenstein appreciates having been authorised to adopt a number of Swiss methods and Swiss emission factors.

As part of a comprehensive project, the Government mandated its Office of Environmental Protection in 2005 to design and establish the NIS in order to ensure full compliance with the reporting requirements of the UNFCCC and its Kyoto Protocol. With regard to the provisions of Art. 5.1 of the Kyoto Protocol, the project encompasses the following elements:

- Collaboration and cooperation of the different offices involved in data collection,
- Upgrading and updating of central GHG emissions data base,
- Setting up a simplified QA/QC system,
- Official consideration and approval of the data.

1.2.2 Overview of Inventory Planning

The planning of the inventory is described in Chapter 1.3.

1.2.3 Overview of Inventory Preparation and Management, Including for Supplementary Information for KP

The Inventory preparation and management is described in Chapter 1.3.

1.3 Inventory Preparation

1.3.1 GHG Inventory and KP-LULUCF Inventory

Figure 1-2 gives a schematic overview of the institutional setting of the process of inventory preparation within the NIS.

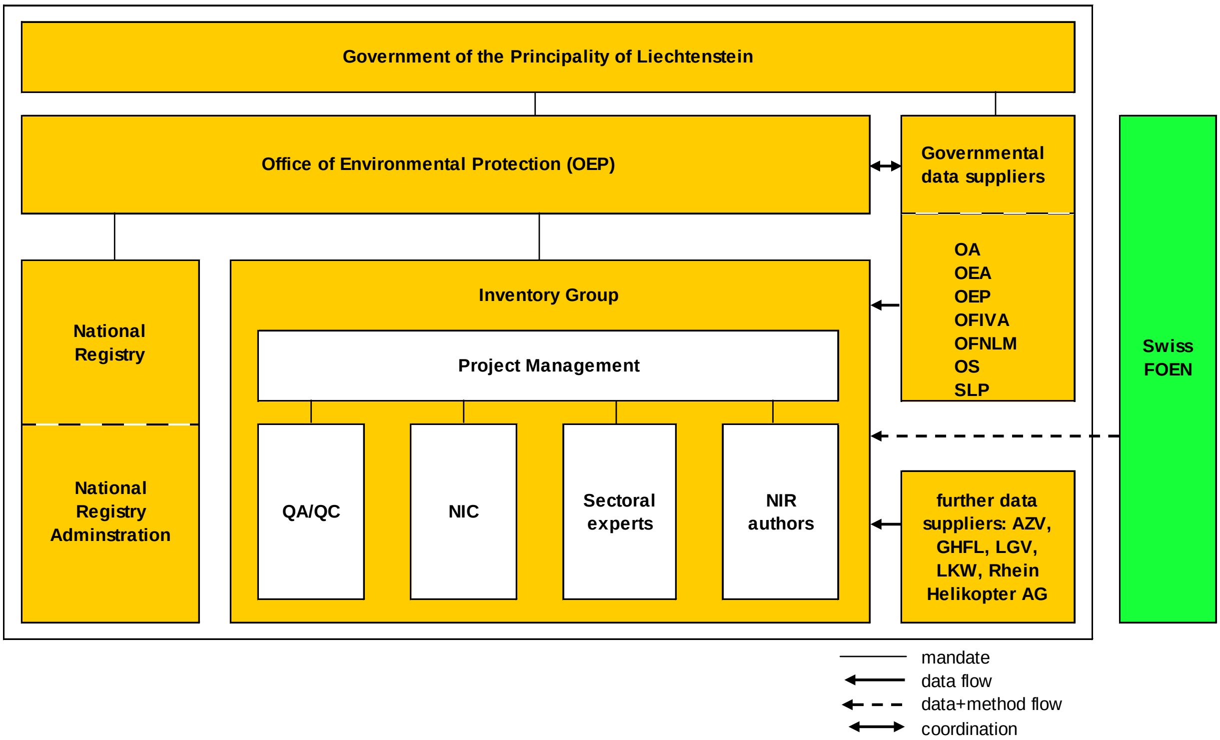


Figure 1-2 National Inventory System: Institutional setting and data suppliers.

The Government of the Principality of Liechtenstein bears the overall responsibility for the NIS. By Liechtenstein's Emission Trading Act (Emissionshandelsgesetz), the Office of Environmental Protection (OEP) is in charge of establishing emission inventories and is therefore also responsible for all aspects concerning the establishing of the National Inventory System (NIS) under the Kyoto Protocol. The responsibility of the OEP for establishing the NIS is also described in the report of the Government to the parliament for ratifying the Kyoto Protocol. The Government mandated the realisation of the NIS to its Office of Environmental Protection.

The Office of Environmental Protection (OEP) plays a major role in the National Inventory System and is acting as the National Registry Administrator. Its representative, the head of the OEP, is the registered National Focal Point. He also coordinates in cooperation with the responsible head of the unit the data flow from the governmental data suppliers to the Inventory Group.

The Inventory group consists of the project manager, the person responsible for the QA/QC activities, the National Inventory Compiler (NIC) who is represented by the project manager and his assistant. Furthermore several external experts belong to the Inventory Group: Sectoral specialists for modelling the greenhouse gas emissions and removals and the NIR authors.

Among the governmental data suppliers there are

- Office of Economic Affairs (OEA)
- Office of Statistics (OS)
- Office of Forest, Nature and Land Management (OFNLM)
- Office of Agriculture (OA)
- Office of Land Use Planning (SLP)
- Office of Environmental Protection (OEP)

Further data suppliers are

- Liechtenstein's Gas Utility / Liechtensteinische Gasversorgung (LGV)
- Electric power company / Liechtensteinische Kraftwerke (LKW)
- Abwasserzweckverband (AZV)
- Heliport Balzers (Rhein Helikopter AG and ROTEX HELICOPTER AG)

In former years, the cooperative society for the storage of gas oil in the Principality of Liechtenstein (Genossenschaft für Heizöl-Lagerhaltung im Fürstentum Liechtenstein, GHFL) delivered data about the annual storage of fuels. However, the cooperative society was closed in 2008.

Cooperation with the Swiss Federal Office for the Environment (FOEN)

The Swiss Federal Office for the Environment (FOEN) is the agency that has the lead within the Swiss federal administration regarding climate policy and its implementation. The FOEN and Liechtenstein's OEP cooperate in the inventory preparation.

- Due to the Customs Union Treaty of the two states, the import statistics in the Swiss overall energy statistics (SFOE 2011) also includes the fossil fuel consumption of the Principality of Liechtenstein except for gas consumption of Liechtenstein which is excluded from SFOE (2011). FOEN therefore corrects its fuel consumption data by subtracting Liechtenstein's liquid fuel consumption from the data provided in the Swiss overall energy statistics. To that aim, OEP calculates its energy consumption and provides FOEN with the data.
- FOEN, on the other hand, makes a number of methods and emission factors available to OEP, mainly transportation, agriculture, LULUCF, synthetic gases, solvents. Liechtenstein has benefited to a large extend from the methodological support by the inventory core group within the FOEN and its readiness to share very openly data and spreadsheet-tools. Its kind support is herewith highly appreciated.

1.3.2 Data Collection, Processing and Storage, including for KP-LULUCF Inventory

Figure 1-3 illustrates the simplified data flow leading to the CRF tables required for reporting under the UNFCCC and under the Kyoto Protocol. For roles and responsibilities of the actors see Figure 1-2.

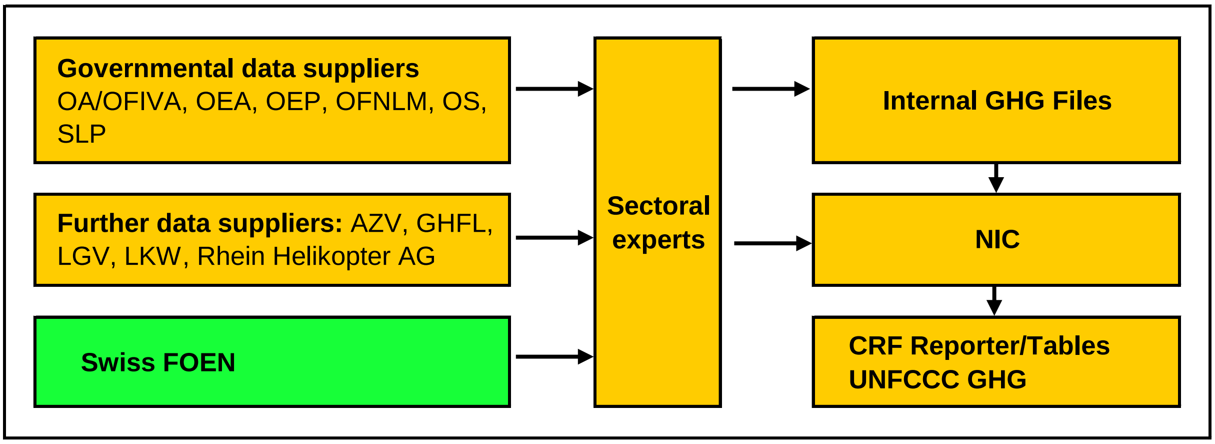


Figure 1-3 Data suppliers and data collection for setting up the UNFCCC GHG Inventory (see Glossary for abbreviations).

1.3.3 QA /QC procedures and extensive review of GHG Inventory and KP-LULUCF Inventory

For QA/ QC procedures including internal reviews see Chapter 1.6.

From 11 to 15 June 2007 an individual review (In-Country Review) took place in Vaduz: The submission documents, the Initial Report and the GHG inventory 1990-2004 including CRF tables and National Inventory Report were objects of the review. Following the recommendations of the expert review team, some minor corrections were carried out in the emission modelling leading to recalculations and some methodological changes (revision of the definition of forests). Due to the recalculation, the time series of the national total of emissions slightly changed and therefore, Liechtenstein's assigned amount has been adjusted by -0.407%. After this correction, Liechtenstein's assigned amount has been fixed to 1055.623 Gg CO_2 equivalents.

In September 2008, 2009, 2010 and 2011 centralized reviews of Liechtenstein's GHG inventories and NIRs of 2007/2008, 2009, 2010 and 2011 took place in Bonn, Germany. A number of recommendations, addressed to Liechtenstein, are relevant for the current submission:

- Two specific potential problems identified by the ERT were documented in a "Saturday Paper" (FCCC 2010). Both potential problems are concerned with KP-LULUCF. See Chap. 16 for further details.
- The "Report of the individual review of the annual submission of Liechtenstein submitted in 2010" (FCCC/ARR/2010/LIE) contains the findings of the ERT including further potential problems beyond the ones mentioned in the "Saturday Paper".
- The "Report of the individual review of the annual submission of Liechtenstein submitted in 2011" containing the findings of the ERT including further potential problems is still under preparation. However, the Synthesis and Assessment II (UNFCCC 2011) and the questions asked by the ERT during the centralzed review in 2001, pointed out several potential problems.

Table 1-1 depicts the recommendations from the ERT which are incorporated into the current report. The recommendations of the reviews (FCCC/ARR 2010,2010a and SIAR (2010)) that could not yet be implemented, are integrated in the Inventory development plan (IDP, see Annex 8.3).

Table 1-1: Incorporated issues according to ERT recommendations from FCCC/ARR (2010) and FCCC/ARR (2010a).

ERT Recommendation	Source	Location
Report results of key category analysis using tables 7.2-7.3 of the IPCC GPG and 5.4.2-5.4.3 of IPCC GPG for LULUCF	para 16 ARR/2010/LIE	Chapter 1.5.1 & Annex 1
Include information explaining the fluctuation in trend	para 39 ARR/2010/LIE	Chapter 2.3, Chapter 3.2.6.9
Include use of bitumen and other fuels (e.g. lubricants) in reporting of feedstocks and non-energy use of fuels	para 39, ARR/2009/LIE	Chpt. 3
Updating the proxy data of the Swiss population for asphalt roofing and road paving with asphalt to increase consistency with the Swiss NIR;	para 32(c) ARR/2010/LIE	Chapter 4.1
Updating the data for solvent and other product use by updating the population data.	para 32(e) ARR/2010/LIE	Chapter 5.x.2.2
Explain increase of CH4 emissions from distribution of natural gas since 1990	para 45, ARR/2009/LIE	Chpt. 3
Provide milk yield statistics	para 53, 57 ARR/2010/LIE	Chpt. 6.2
Description of planned improvements in the NIR	para 54 ARR/2010/LIE	Chpt. 6
Improvement of transparency and description	para 56 ARR/2010/LIE	Chpt. 6
More detailed justification for use of Swiss methodologies	para 56, 58 ARR/2010/LIE	Chpt. 6
Improve description for calculation of fertilizer application	para 61, ARR/2009/LIE	Chpt. 6.5
Correct description of uncertainty analysis	para 63, ARR/2010/LIE	Chpt. 7
Provide land -use change matrices, provided for three different years, not for every year due to efficiency reasons	para 65, ARR/2010/LIE	Chpt. 7.2.4 and Annex
Provide description of distinction between managed and unmanaged in the NIR	para 66, ARR/2010/LIE	Chpt. 7.2.1
Use of latest, new area statistics	para 68, ARR/2010/LIE	Chpt. 7
Improve references of EF and AD	para 69, ARR/2010/LIE	Chpt. 7
Describe calculation in the NIR correctly, analogous to calculation for CRF	para 70, 71, ARR/2010/LIE	Chpt. 7
Revise factor for loss of soil carbon from deforestation of 46 Mg C /ha	para 87 ARR/2010/LIE	Chpt. 11

1.4 Methodologies and Data Sources

1.4.1 GHG Inventory

1.4.1.1 General Description

The emissions are calculated based on the standard methods and procedures of the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC 1997a, 1997b, 1997c) and IPCC Good Practice Guidances (IPCC 2000, IPCC 2003) as adopted by the UNFCCC.

The emissions are modelled by using country specific activity data. Country specific emissions factors are applied if available. A number of default emission factors from IPCC are used. For a majority of emission sources, however, emission factors are adopted from the Swiss GHG inventory after checking their applicability. In those cases, the emission factors are reported as country specific. It is noteworthy that there is a very close relationship between Liechtenstein and Switzerland based on the Customs Union Treaty between the two countries (see Section 1.2.1). The Customs Union Treaty with Switzerland has a significant impact on environmental and fiscal strategies. Many Swiss environmental provisions and climate-protection regulations are also applicable in Liechtenstein or are implemented into Liechtenstein law on the basis of specific international treaty rules. **Therefore, a number of emission factors are adopted from Switzerland assuming that the Swiss emission factors actually represent the emission standards more accurately than default emission factors.** This assumption especially holds for

- the sector Energy due to the same fuel quality standards and regulations standards for exhaust gases of combustion and motor vehicles,

- the emission of synthetic gases due to similar consumer’s product and attitude,
- the sector Agriculture due to similar stock farming and cultivation of land,
- the sector LULUCF due to – again – similar geographic, meteorological and climatic circumstances for forestry.

In the following paragraph, a short summary of the methods used is given for every sector.

1 Energy

- Emissions from 1A Fuel Combustion Activities: Activity data is taken from the National Energy Statistics (including consistency modifications) and from census for the fuel sales of gasoline and diesel oil. The methods are country specific.
- Emissions from 1B Fugitive Emissions from Fuels: The Swiss method is applied corresponding country specific.

2 Industrial Processes

- HFC and PFC emissions from 2F1 Refrigeration and Air Conditioning Equipment are reported and are calculated with the rule of proportion applied on the Swiss emissions using country specific activity data as proxy for the conversion (e.g. no. of inhabitants).
- SF_6 emissions from 2F8 Electrical Equipment are reported based on country specific data.
- CO and NMVOC emissions from 2A5 Asphalt Roofing and 2A6 Road Paving with Asphalt. The emissions are estimated from the Swiss emissions using the number of inhabitants as a proxy for the rough estimate of Liechtenstein's emissions.
- Other emissions from industrial processes (CO_2, CH_4, N_2O) are not occurring.

3 Solvent and Other Product Use

- Emissions 3A-3D: the emissions are estimated from the Swiss emissions using the number of inhabitants as a proxy for the rough estimate of Liechtenstein's emissions.

4 Agriculture

- Emissions are reported for 4A Enteric Fermentation, 4B Manure Management and 4D Agricultural Soils by applying Swiss methods (country specific) combined with Liechtenstein specific Activity Data as far as available.

5 LULUCF

- Emissions and removals are reported for 5A to 5F. The methods are adopted from Switzerland (country specific).

6 Waste

- Emissions are modelled by applying the following methods: 6A T2, 6B CS (CH_4) and D (N_2O), 6C T2 and 6D CS.

1.4.1.2 Specific Assumptions for the Year 2010

For the modelling of its emission, Liechtenstein uses several emission factors stemming from the Swiss GHG inventory. Important examples are the implied emission factors for 1A3b Road Transportation. Currently, the emissions 2010 of the Swiss inventory 2012 are not yet available in their final version, therefore the implied emission factors 2010 are not available either. For the time being, as annual variation of the Swiss implied emission factors is very small, **implied emission factors 2009 are used as a preliminary estimate for the implied emission factors 2010**. The following sectors are concerned

- Energy: 1A3b
- Ind. Process: 2A5–2A6, 2F1–2F8
- Solvent and other Product Use: 3A, 3B, 3C, 3D
- Agriculture: 4A, 4B, 4D

For the submission in April 2013, the emissions 2010 will be recalculated for the above categories using the final Swiss implied emission factors 2010.

Table 1-2 Notation keys for applied methods and emission factors (see also CRF tables Summary3s1, Summary3s2).

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1. Energy	**CS,T1,T2**	**CS**	**CS,T1,T2,T3**	**CS,D**	**CS,T1,T2,T3**	**CS,D**
A. Fuel Combustion	CS,T1,T2	CS	CS,T1,T2,T3	CS,D	CS,T1,T2,T3	CS,D
1. Energy Industries	T2	CS	T2	CS	T2	CS,D
2. Manufacturing Industries and Construct	T2	CS	T2	CS	T2	D
3. Transport	T1	CS	T3	CS,D	T3	CS,D
4. Other Sectors	CS,T1,T2	CS	CS,T1,T2	CS	CS,T1,T2	CS,D
5. Other	T1	CS	T1	CS	T1	CS
B. Fugitive Emissions from Fuels	NA	NA	T3	CS	NA	NA
1. Solid Fuels	NA	NA	NA	NA	NA	NA
2. Oil and Natural Gas	NA	NA	T3	CS	NA	NA
2. Industrial Processes	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
A. Mineral Products	NA	NA	NA	NA	NA	NA
B. Chemical Industry	NA	NA	NA	NA	NA	NA
C. Metal Production	NA	NA	NA	NA	NA	NA
D. Other Production	NA	NA				
E. Production of Halocarbons and SF_6						
F. Consumption of Halocarbons and SF_6						
G. Other	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**CS**	**CS**			**CS**	**CS**
4. Agriculture			**T2**	**CS,D**	**CS,T1b**	**D**
A. Enteric Fermentation			T2	CS		
B. Manure Management			T2	D	CS	D
C. Rice Cultivation			NA	NA		
D. Agricultural Soils			NA	NA	CS,T1b	D
E. Prescribed Burning of Savannas			NA	NA	NA	NA
F. Field Burning of Agricultural Residues			NA	NA	NA	NA
G. Other			NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	**T2**	**CS**	**NA**	**NA**	**T2**	**CS**
A. Forest Land	T2	CS	NA	NA	NA	NA
B. Cropland	T2	CS	NA	NA	T2	CS
C. Grassland	T2	CS	NA	NA	NA	NA
D. Wetlands	T2	CS	NA	NA	NA	NA
E. Settlements	T2	CS	NA	NA	NA	NA
F. Other Land	T2	CS	NA	NA	NA	NA
G. Other	NA	NA	NA	NA	NA	NA
6. Waste	**T2**	**CS**	**CS,T2**	**CS**	**CS,D,T2**	**CS,D**
A. Solid Waste Disposal on Land	NA	NA	T2	CS		
B. Waste-water Handling			CS	CS	D	D
C. Waste Incineration	T2	CS	T2	CS	T2	CS
D. Other	NA	NA	CS	CS	CS	CS
7. Other (as specified in Summary 1.A)	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

2. Industrial Processes	HFCs		PFCs		SF_6	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
E. Production of Halocarbons and SF_6	NA	NA	NA	NA	NA	NA
F. Consumption of Halocarbons and SF_6	CS	CS,D	CS	CS	T3	CS

1.4.1.3 Reference Approach for the Energy Sector

Liechtenstein has carried out the Reference Approach to estimate energy consumption and CO_2 emissions for the energy sector. The results are shown in Chapter 3.2.1..

1.4.2 KP-LULUCF Inventory

The information in this Inventory is provided in accordance with Decision 15/CP.10 (FCCC/CP/2004/10/Add.2) and based on the information given in Liechtenstein's Initial Report (OEP 2006a) and the Corrigendum to the Initial Report of 19 Sep 2007 (OEP 2007b).

According to paragraph 25 of the annex to decision 13/CMP.1, Liechtenstein had to determine for each activity of the LULUCF sector whether removal units (RMUs) shall be issued annually or for the entire commitment period. Liechtenstein has chosen to **account annually** for emissions and removals from the LULUCF sector (see Chapter 7 of the Initial Report OEP 2006a).The decision remains fixed for the entire first commitment period.

Liechtenstein adopts the forest definition of the Swiss Land Use Statistics (AREA) of the Swiss Federal Statistical Office. AREA provides an excellent data base to derive accurate, detailed information of not only forest areas, but all types of land use and land cover. Thus, AREA offers a comprehensive, consistent and high quality data set to estimate the surface area of the different land use categories in reporting under the Kyoto Protocol. For Liechtenstein, the Land Use Statistics has been built up identically to Switzerland (same method and data structures, same realisation).

The following forest definition has been used (OEP 2007b):

- minimum area of land: 0.0625 hectares (with a minimum width of 25 m)
- minimum crown cover: 20 per cent
- minimum height of the dominant trees: 3 m (dominant trees must have the potential to reach 3 m at maturity in situ)

In extension of the method applied for the LULUCF sector, KP-LULUCF requires the distinction between human-induced deforestation and not human-induced changes of forest land into other land categories. Deforestation data are taken from Liechtenstein's official deforestation statistics ("Rodungsstatistik"), as deforestation is generally prohibited by law and every deforestation in Liechtenstein has therefore to be authorised (see also 11.1.1.1).

1.5 Brief Description of Key Categories

The key category analysis (KCA) is performed according to the IPCC Good Practice Guidance (IPCC 2000, chapter 7) and the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003, chapter 5.4). The used methodology is a Tier 1 level and trend assessment with the proposed threshold of 95%. The analysis is performed four times, for the base year 1990 and the latest year 2010, both years with and without LULUCF categories.

1.5.1 GHG Inventory

1.5.1.1 KCA without LULUCF categories

For 2010, among a total of 123 categories, 15 have been identified as key categories with an aggregated contribution of 95.2% of the national total emissions (see Table 1-3). 15 among the 15 are key categories due to the level assessment, 11 due to the trend assessment (see Table 1-4).

From 15 key categories, 11 are out of the energy sector, contributing 84.5% to total CO_2 equivalent emissions in 2010. The other key categories are from sectors Industrial Processes (2.8%) and Agriculture (7.8%).

There are five major key sources which contribute together 66.4% of the key sources:

- 1A3b Energy, Fuel Combustion, Road Transportation, gasoline: CO_2, level contribution 20.0%,
- 1A4a Energy, Fuel Combustion, Other Sectors, Commercial/Institutional, liquid fuels: CO_2, level contribution 13.3%.

- 1A3b Energy, Fuel Combustion, Road Transportation, diesel: CO_2, level contribution 12.7%,
- 1A4b Energy, Fuel Combustion, Other Sectors, Residential, gaseous fuels: CO_2, level contribution 11.3%.
- 1A4a Energy, Fuel Combustion, Other Sectors, Commercial/Institutional, gaseous fuels: CO_2, level contribution 9.1%.

Compared to the previous submission for the reporting year 2009, there is no change in the key categories.

Further details are shown Table 1-3, and the complete Key Category Analysis is provided in Annex 1.1.

For the base year 1990, the level analysis is given in Table 1-4. There are 12 level key categories, which were also key categories in 2009.

Compared to the KCA analysis for 1990, three additional categories are key categories in the KCA analysis for 2010: 1A1 Energy, Fuel Combustion, Energy Industries, Gaseous Fuels, CO_2; 1A3b Energy, Fuel combustion, Road Transportation, Gaseous Fuels, CO_2 and 2F Industrial Processes, Consumption of Halocarbons and SF6, HFC.

Table 1-3 List of Liechtenstein's 15 key categories 2010. Sorted by contribution in level.

Key Category Analysis 2010 (without LULUCF) IPCC Source Categories (and fuels if applicable)					Direct GHG	Share of Total Emissions	Cumulative Total	Result of assessment
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	20.0%	20.0%	KC Level & KC Trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	13.3%	33.3%	KC Level & KC Trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	12.7%	46.0%	KC Level & KC Trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	11.3%	57.3%	KC Level & KC Trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	9.1%	66.4%	KC Level & KC Trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	5.2%	71.5%	KC Level & KC Trend
4A	4. Agriculture	A. Enteric Fermentation			CH4	4.5%	76.0%	KC Level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	4.4%	80.4%	KC Level & KC Trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	4.4%	84.8%	KC Level & KC Trend
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			HFC	2.8%	87.7%	KC Level & KC Trend
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	2.2%	89.9%	KC Level
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	1.5%	91.4%	KC Level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CO2	1.4%	92.8%	KC Level & KC Trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	1.3%	94.1%	KC Level & KC Trend
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	1.1%	95.2%	KC Level

Table 1-4 List of Liechtenstein's 12 key categories in 1990. Sorted by contribution in level.

Key Category Analysis 1990 (without LULUCF) IPCC Source Categories (and fuels if applicable)					Direct GHG	Share of Total Emissions	Cumulative Total	Result of assessment
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	26.4%	26.4%	KC Level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	24.9%	51.4%	KC Level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	8.2%	59.6%	KC Level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	8.2%	67.8%	KC Level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	7.2%	75.0%	KC Level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	6.5%	81.4%	KC Level
4A	4. Agriculture	A. Enteric Fermentation			CH4	4.6%	86.0%	KC Level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	3.8%	89.8%	KC Level
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	2.4%	92.2%	KC Level
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	1.2%	93.4%	KC Level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1.1%	94.4%	KC Level
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	1.0%	95.5%	KC Level

1.5.1.2 KCA including LULUCF categories

According to IPCC Good Practice Guidance for LULUCF (IPCC 2003), Section 5.4.2, the set of key categories consists of all non-LULUCF key categories that result from the KCA without LULUCF combined with all LULUCF-key-categories that result from the KCA with LULUCF.

The key category analysis including LULUCF categories is also carried out for 1990 and 2010. In the KCA 2010 including LULUCF categories there are in total 137 categories. 19 of them are key categories. Four of the key categories are from the LULUCF sector and contribute with a total of 10.6% to the total emissions. The largest category is 5A1 Forest Land remaining Forest Land, CO_2 (7.0%); the other LULUCF key categories are of minor importance: 5B1 Cropland remaining Cropland, CO_2 (1.7%), 5C1 Grassland remaining Grassland, CO_2 (0.6%) and 5E2 Land converted to Settlements, CO_2 (1.3%).

Compared to the Key Category Analysis in the previous submission for the reporting year 2009, there is one LULUCF category which is not key categories any more: 5C2 Land converted to Grassland, CO_2. 5C1 Grassland remaining Grassland, CO_2 is a new key category in 2010.

Further details are shown Table 1-5, and the complete Key Category Analysis is provided in Annex 1.2.

In the KCA 1990 including LULUCF categories, 15 categories appear as key categories. Three of the key categories are from the LULUCF sector.

Compared to the KCA analysis 2009 for 1990 including LULUCF, one LULUCF category is not key anymore: 5C1 Grassland remaining Grassland, CO_2.

Table 1-5 Liechtenstein's key categories in 2010 and in 1990 combined without and with LULUCF categories

Key Category Analysis 2010 (including LULUCF) IPCC Source Categories (and fuels if applicable)					Direct GHG	Share of Total Emissions
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	1.2%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	4.6%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	3.9%
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	11.2%
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CO2	1.2%
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	17.6%
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	8.0%
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	11.7%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	9.9%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	3.9%
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	1.3%
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			HFC	2.5%
4A	4. Agriculture	A. Enteric Fermentation			CH4	4.0%
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	2.0%
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	0.9%
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO2	7.0%
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO2	1.7%
5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO2	0.6%
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO2	1.2%

Key Category Analysis 1990 (including LULUCF) IPCC Source Categories (and fuels if applicable)					Direct GHG	Share of Total Emissions
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	6.4%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	7.3%
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	5.7%
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	23.4%
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	3.4%
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	22.1%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1.0%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	7.3%
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	0.9%
4A	4. Agriculture	A. Enteric Fermentation			CH4	4.0%
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	2.1%
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	1.1%
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO2	7.2%
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO2	1.7%
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO2	1.3%

1.5.2 KP-LULUCF Inventory

As stated in the IPCC Good Practice Guidance for LULUCF (IPCC 2003), the basis for assessment of key categories under Articles 3.3 and 3.4 of the Kyoto Protocol is the same as the assessment made for the UNFCCC inventory. Note that Liechtenstein has elected to not account for LULUCF activities under Article 3.4 during the first commitment period (OEP 2006a). Therefore only the categories afforestation/reforestation and deforestation are reported for the KP Inventory.

Among the key categories from the LULUCF sector in the UNFCCC inventory, there are three categories which have a relationship to afforestation/reforestation or deforestation, according to table 5.4.4 in the IPCC Good Practice Guidance for LULUCF:

- 5D2 Land converted to Wetlands: related to deforestation
- 5E2 Land converted to Settlements: related to deforestation

Afforestation occurs in more than one category of the UNFCCC inventory. As recommended by the IPCC Good Practice Guidance for LULUCF, in this case the total emissions and removals from the activity are considered for purposes of the key category analysis. The total from the activity afforestation in 2010, as reported with the present submission, is a removal of 3.22 Gg CO_2. The smallest category that is identified as key in the UNFCCC inventory (combined KCA without and with LULUCF categories) is 4D3 Indirect Emissions from Agricultural Soils with 2.47 Gg CO_2 emissions. This means that the total for afforestation (3.26 Gg) is greater than the emissions from the smallest category that is identified as key in the UNFCCC inventory. Therefore Afforestation is considered to be a key category whereas Deforestation with only 0.14 Gg CO_2 emissions is not a key category.

1.6 Quality Assurance and Quality Control (QA/QC) Including Verification and Confidentiality Issues

1.6.1 QA /QC Procedures

1.6.1.1 Terms and objectives

According to the IPCC Good Practice Guidance (IPCC 2000) the major elements of a QA/QC system are:

- an inventory agency responsible for coordinating QA/QC activities;
- a QA/QC plan;
- QC procedures;
- QA review procedures;
- reporting, documentation, and archiving procedures.

The state of implementation of these quality elements is described in the following chapters. One has to note that Liechtenstein's QA/QC system accounts for the **specific circumstances of the Principality of Liechtenstein**: Due to the smallness of the State, not every process, data flow and arrangement does need to be established by a formal agreement due to short "distances" within the administration and due to a high degree of acquaintance between the persons involved. Therefore, the National System manages with little number of written documents.

1.6.1.2 Objectives of the quality system

The quality management shall enable the party to principally fulfil the requirements of the articles 3, 5 and 7 of the Kyoto Protocol. Specifically, it shall ensure and improve the quality of GHG inventory that means a continuous improvement **of transparency, consistency, comparability, completeness and confidence**. In detail, it serves

- for providing checks to ensure data integrity, correctness and completeness;
- to identify errors and omissions,
- to reduce the uncertainties of the emission estimates,
- to document and archive inventory material.

1.6.1.3 Responsible agency for coordinating QA/QC activities

The QA/QC activities are coordinated by the quality manager of the GHG Inventory Group. The responsible person is Mr. Andreas Gstoehl, head of the unit Air Pollution Control, Noise and Climate (e-mail: Andreas.Gstoehl@aus.llv.li, phone: +423 236 61 86) in the Office of Environmental Protection (OEP). The QA/QC activities are organised within the Inventory Group, see National System represented in Figure 1-2.

Operational tasks are delegated to the lead NIR author. He distributes checklists to the project manager being also the National Inventory Compiler, to the sectoral experts, and to other NIR authors. They fill in the procedures that they carried out. The lists are then sent back to the quality manager, who confirms the performance of the QA/QC activities. The activities are documented in the NIR (see Annex 8).

1.6.1.4 QC procedures

Quality control (QC) is defined by: “System of routine technical activities to measure and control the quality of the inventory as it is being developed.” (IPCC 2000).

Overall Activities

The following QC activities are carried out:

- The annual cycle for inventory preparation contains several meetings of the Inventory Group and several meetings of governmental and other data suppliers with the OEP. On these meetings the activities, responsibilities and schedule for the inventory preparation process are being organised and determined.
- Regular meetings of the group “Umwelt und Raum” (environment and spatial planning). The group is formed by the heads of the OEP, SLP, OFNLM and the minister for the environment. It prepares policy matters for the attention of the Government including climate affairs.
- The project manager also being the national inventory compiler (NIC), the sectoral experts, and the NIR authors accomplish a number of QC activities:

The NIR authors check the emission results produced by the sectoral experts, for consistency of cross-cutting parameters, correctness of emissions aggregation, and completeness of the GHG inventory. They compare the methods used with IPCC Good Practice Guidance, check the correct compiling of the methods in the NIR, the correct transcription of CRF data into NIR data tables and figures, the consistency between data tables and text in the NIR, and the completeness of references in the NIR. Further they are responsible for the correctness of the key source and the uncertainty analysis.

The sectoral experts check the description of methods, numbers and figures in the NIR.

The NIC checks the integrity of the database files, the consistency of time series, the correct and complete inputs into the CRF Reporter.

Further staff members of the OEP carry out a proof reading of single sectors.

The project manager executes an overall checking function for the GHG inventory and the NIR: he monitors the GHG emission modelling and the key category analysis. He checks the NIR for correctness, completeness, transparency and quality, checks for the complete archiving of documents, and the completeness of the CRF submission document.

It may be mentioned that the OEP enlarged its staff in the unit Climate Protection in the beginning of 2007 by two more collaborators. They are responsible for emission modelling, GHG inventory, implementation of the emission trading system, national emissions trading registry, national allocation plan, Kyoto mechanisms (JI, CDM).

Specific activity

The CRF tables exported from the CRF Reporter software underwent an iterative quality control in a triple check:

- The results for 2010 were compared with the results 2009 within the current CRF,
- the results for 2009 were compared between the current CRF tables and the CRF tables of submission 2011,
- the results for the base year 1990 were compared between the current CRF tables and the CRF tables of submission 2011.

For each check, the CRF table cells were marked in green if values were identical, in grey if they differed by no more than 20%, in orange if they differed by 20% to 50%, and in red if they differed by more than 50%. The findings were discussed among the core group members and the modelling specialists. All differences were investigated and the reasons for the differences sought. This procedure led to the identification of several errors, which were subsequently corrected before submission.

1.6.1.5 Documentation of the QC Activities

For the submission 2008, the QC activities had been documented for the first time by means of checklist. The lists are updated for the current submission and are shown in the Annex 8. The classification of the QC activities follows the IPCC GPG table 8.1 (IPCC 2000). The following persons are involved in the QC activities:

- Sectoral experts for energy, industrial processes etc.
- NIC / Project manager
- NIR authors

Special attention of the QC activities for emissions has been directed to the key categories.

1.6.1.6 QA Review Procedures

Quality assurance (QA): System of activities that include a “system of review procedures conducted by personnel not directly involved in the inventory compilation development process, to verify that data quality objectives were met, ensure that the inventory represents the best possible estimate of emissions and sinks given the current state of scientific knowledge and data available, and support the effectiveness of the QC programme” (IPCC 2000).

Liechtenstein's NIS quality management system follows a Plan-Do-Check-Act-Cycle (PDCA-cycle), which is a generally accepted model for pursuing a systematic quality performance according to international standards. This approach is in accordance with procedures described in decision 19/CMP.1 and in the IPCC Good Practice Guidance.

Liechtenstein carries out the following QA activities:

- Internal review: The draft NIR is passing through an internal review. The project manager also being the NIC, the project manager assistant, two specialised staff members of the climate unit, and other staff member of the OEP are proofreading the NIR or parts of it (personnel not directly involved in the preparation of a particular section of the inventory). They document their findings in checklists, which are sent back to the NIR authors (see Annex 8)
- The Swiss inventory management charges external experts for sectoral QA activities to review the Swiss GHG inventory. Since a number of Swiss methods and Swiss emission factors are used for the preparation of the Liechtenstein inventory, the results of the Swiss QA activities have to be checked and analysed by Liechtenstein's experts. Positive reviews may be interpreted as positive for Liechtenstein too, and problematic findings must not only be taken account for in Switzerland but also in Liechtenstein. The following sectors have already been reviewed:

A consulting group (not involved in the GHG emission modelling) was mandated to review the two sectors Energy and Industrial Processes with respect to methods, activity data, emission factors, CRF tables, NIR chapter (Eicher and Pauli 2006). The results were documented in a review report and communicated to Liechtenstein's Inventory Group. The consequences for the main findings have been evaluated for Liechtenstein's GHG inventory and for the NIR for submission December 2006.

The Swiss Federal Institute of Technology was mandated to review the methane emissions of agriculture with respect to methods, activity data, emission factors. The results were documented in two reports (Soliva 2006a, 2006b) and communicated to Liechtenstein's Inventory Group. The consequences for the main findings have been evaluated for Liechtenstein's GHG inventory and for the NIR for submission December 2006.

The waste sector of Switzerland was reviewed by a peer expert group in 2009. The reviewers conclude that waste related emissions are calculated in a plausible way and that results from the report are plausible. The emission factors as well as activity data are based on reliable and solid sources. For details see Rytec (2010)

An expert peer review of the LULUCF sector of the Swiss GHG inventory took place in 2010. The reviewers conclude that "LULUC sector of the Swiss green house gas inventory proved to be of superior quality, good applicatory characteristics and scientifically sound applied definitions and methodology". For details see VTI (2010).

For the Swiss NIR, an internal review takes place annually shortly before the submission. Every chapter of the NIR is being proofread by specialists not involved in the emission modelling or in the NIR editing. The internal review is organised by the quality officer and the results are compiled by the same person that is also compiling Liechtenstein's NIR (lead author J. Heldstab, INFRAS). The results of the Swiss review are therefore communicated to Liechtenstein's Inventory Group. Where methods and results are concerned that are relevant for Liechtenstein too, the consequences were taken into account. This procedure has been performed in the last and the current submissions (May and December 2006, May 2007, February 2008, April 2009, April 2010, April 2011). It will also be repeated for future submissions.

- The applicability of Swiss methodologies and emission factors to Liechtenstein's GHG inventory is reviewed as well: Before Swiss methods are applied, they are discussed with the experts of Liechtenstein's administration. This process has taken place before the submission in December 2006 for the sectors Energy, Industrial Processes, Solvent and Other Product Use, Agriculture and Waste, for the sector LULUCF before the submission in February 2008. Since then, the issue is a permanent point on the agenda of the annual kick-off meetings of the Inventory Group: Potential modifications or updates of the Swiss emission factors are discussed and checked upon their abblicability for Liechtesntein's GHG inventory

1.6.1.7 Archiving Procedures

The electronic files of Liechtenstein's GHG inventory are all saved by the backup system of Liechtenstein's administration.

Every computer belonging to the administration, including the computers of the Office of Environmental Protection, are connected to a central network. The data of the server systems, file-clusters and database servers, are being saved in a tape-library. Due to safety reasons, the tape-library is not in the computing centre but in a building of the National police: In case of a total lost of the computing centre, the data are still available.

There are several backups

- daily incremental saved up to one month (4 weeks)
- Weekly full backup saved up to two months
- Monthly full backup saved up to one year

The backup files are being initialised via scheduler of the master server. The data are written via network onto one of the LTO 2 Drives (tape). The master server manages the handling of the tapes. Backups are checked daily via Activity Monitor. If a backup is not carried out, it may be caught up manually. Since daily restores of user data is carried out, there is a guarantee for keeping the data readable.

For archiving reasons, the backup tapes are being doubled four times a year. The duplicates are not being overwritten during five years.

In addition to the administrational archiving system, the external experts of Acontec AG, who are mandated with the emission modelling and CRF generation, save all CRF and background tables yearly on CD ROM /DVD ROM. Also the data generated in the NIR compilation process such as QA/QC, KCA, unvertainty analysis, review documents are saved on DVD by INFRAS. The disks are stored in a bank safe of the Liechtensteinische Landesbank (Liechtenstein's National Bank).

Therefore archiving practices are in line with paragraph 16(a) of the annex to decision 19/CMP.1

1.6.2 Verification Activities

Verification Activities have taken place in various steps of the development of the Inventory. As Liechtenstein compiles its Inventory in close collaboration with Switzerland concerning methods and models used, there is a continuous international comparison between the two Inventories going on.

The same emission factors as in the Swiss NIR are applied. Therefore, those factors are basically checked when copied from the Swiss NIR and correlation thus depends on the activity data. As both countries have similar methodologies used, comparable economic structure and similar liquid/gaseous fuels mixes and vehicle fleet composition, comparison of total per capita CO_2 emission indicates completeness of source categories.

If the national total emissions (without LULUCF) of the two countries are compared, very similar and highly correlated trends may be found. In 1990, Liechtenstein's emissions were 0.44% of the Swiss emissions. After a slight increase in past years up to 0.46%, in the share in 2010 reached again 0.44%. In the same period, the share of inhabitants increased slightly from 0.43% to 0.45%. This correlation may be interpreted as a simple form of verification,since Liechtentsein has used the same or similar Methods and EF for many sectors.

Another indirect verification may be derived from the ambient air pollutant concentration measurements. Liechtenstein is integrated in a monitoring network of the Eastern cantons of Switzerland (www.ostluft.ch). The results are commonly analysed and published (Ostluft 2011). They show that the local air pollution levels of NO_2, O_3, PM10 in Liechtenstein vary in the same range as in the Swiss neighbouring measurement sites.

1.6.3 Treatment of Confidentiality Issues

In Liechtenstein all Activity Data and Emission Factors are publicly available and not subject to confidentiality treatment.

1.7 Uncertainty Evaluation

1.7.1 GHG Inventory

1.7.1.1 Data Used

Data on uncertainties is not provided explicitly for most key data sources. In this situation, the authors of the NIR chapters together with the involved experts generated first estimates of uncertainties based on IPCC Good Practice Guidance default values, uncertainty data from the Swiss NIR (FOEN 2011) and expert estimates.

All uncertainty figures are to be interpreted as corresponding to half of the 95% confidence interval. Distributions are assumed to be symmetric for Tier 1 analysis.

Uncertainties in the GWP-values were not taken into account in the inventory uncertainty estimates.

1.7.1.2 Uncertainty Estimates

For key categories individual uncertainties are used. For non-key categories the NIR provides qualitative estimates of uncertainties. The terms used are high, medium and low data quality. In order to extend the quantitative uncertainty analysis to every non-key category the default values of applied combined uncertainty presented in Table 1-6 are used. They are motivated by the comparison of uncertainty analyses of several countries carried out by de Keizer et al. (2007), as presented at the 2nd Internat. Workshop on Uncertainty in Greenhouse Gas Inventories (Vienna 27-28 Sep 2007), and by Table A1-1 of IPCC Guidelines, Vol. 1, Annex 1, Managing uncertainties (IPCC 1996).

Table 1-6 Semi-quantitative uncertainties (2 σ) for non-key categories.

Gas	Uncertainty category	Relative uncertainty
CO_2	low medium high	2% 10% 40%
CH_4	low medium high	15% 30% 60%
N_2O	low medium high	40% 80% 150%
HFC	medium	20%
PFC	medium	20%
SF_6	medium	20%

1.7.1.3 Results for Tier 1 Uncertainty Evaluation

A quantitative uncertainty analysis has been carried out following IPCC Good Practice Guidance Tier 1 methodology (IPCC 2000, p. 6.13ff.). First, uncertainties of activity data and emission factors are estimated separately. The combined uncertainty for each source is then calculated using a Rule B approximation (IPCC 2000 p. 6.12). Finally, the Rule A approximation is used to obtain the overall uncertainty in national emissions and the trend in national emissions between the base year and the current year. For the uncertainty analysis with LULUCF, uncertainties of the LULUCF categories from Switzerland are applied.

The resulting Tier 1 uncertainty in the national total annual CO_2 equivalent emissions **without LULUCF** is estimated to be 6.45% (level uncertainty). Trend uncertainty is 8.43%.

The resulting Tier 1 uncertainty in the national total annual CO_2 equivalent emissions of the **LULUCF sector** is estimated to be 3.22% (level uncertainty). Trend uncertainty of LULUCF sector is 1.26%.

The resulting Tier 1 **total inventory uncertainty** in the national total annual CO_2 equivalent emissions **including LULUCF** sector is estimated to be 7.20% (level uncertainty). Trend uncertainty is 8.52%.

Details on the uncertainty estimates of specific sources are provided in the sub-sections on "Uncertainties and Time-Series Consistency" in each of the chapters on source categories below.

The result for calculations without LULUCF is slightly lower compared to the previous submission (6.81% level, 9.49% trend uncertainty, see OEP 2011a). The reason is that there is a decrease in the activity data for liquid fuels.

The result for calculations with LULUCF is significantly lower compared to the previous submission (128.71% level, 39.64% trend uncertainty, see OEP 2011a). The reason is that the uncertainty calculations have been revised and a calculation error has been detected. The uncertainties (overall and trend) for the LULUCF-sector has been calculated on the basis of the sum of LULUCF emissions instead of the overall emissions. This provoked a high uncertainty as the sum of LULUCF emissions is low compared to the overall emissions. The calculations have been revised for the present submission and for the LULUCF, the change is significant while for the other categories, the change is small.

The overall uncertainty is still determined by the rather high activity data uncertainty of liquid fuels. This is due to the fact that Liechtenstein, forming a customs and monetary union with Switzerland, has no own customs statistics of imports of oil products, and activity data has to be based on soundings with suppliers, being of heterogeneous quality.

Please note that the current results of the Tier 1 uncertainty analysis for GHG emissions from key sources in Liechtenstein do not (fully) take into account the following factors that may further increase uncertainties:

- Correlations that exist between source categories that have not been considered,
- Uncertainties due to the assumption of constant parameters, e.g. of constant net calorific values for fuels for the entire period since 1990,
- Uncertainties due to methodological shortcomings, such as differences between sold fuels and actually combusted fuels (stock-changes in residential tanks) for liquid fossil fuels,
- For uncertainties of non-key categories, only a simplified uncertainty assessment has been made.

Table 1-7 Tier 1 Uncertainty calculation and reporting for sources in Liechtenstein, 2010 (IPCC 2000)

IPCC GPG Table 6.1
Tier 1 Uncertainty Calculation and Reporting

A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category	Gas	Base year emissions 1990	Current Year 2010 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emission in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data	Calc/Input						
		Gg CO2 equivalent	Gg CO2 equivalent	%	%	%	%	%	%	%	%	%
1. CO2 emissions from Fuel Combustion												
1A 1. Energy A. Fuel Combustion Gaseous fuels	CO2	27.81	65.93	5.0	4.6	6.8	1.972	0.1688	0.2988	0.78	2.11	2.25
1A 1. Energy A. Fuel Combustion Gas oil and LPG	CO2	94.58	51.47	20.0	0.61	20.0	4.534	-0.2071	0.2333	-0.13	6.60	6.60
1A 1. Energy A. Fuel Combustion Gasoline	CO2	60.53	46.62	10.0	1.36	10.1	2.071	-0.0709	0.2113	-0.10	2.99	2.99
1A 1. Energy A. Fuel Combustion Diesel	CO2	18.43	34.53	15.0	0.47	15.0	2.281	0.0704	0.1565	0.03	3.32	3.32
1A 1. Energy A. Fuel Combustion Jet Kerosene	CO2	0.08	0.14	15.0	1.16	15.0	0.009	0.0003	0.0006	0.00	0.01	0.01
1A 1. Energy A. Fuel Combustion Solid fuels	CO2	0.09	0.00	20.0	5.0	20.6	0.000	-0.0004	0.0000	0.00	0.00	0.00
Total CO2 Emissions Fuel Combustion	CO2	201.53	198.70									
Total Uncertainties CO2 Emissions Fuel Combustion					Overall uncertainty in the year (%)		5.83				Trend uncertainty (%)	8.28

A	B	C	D	E	F	G	H	I	J	K	L	M
		Gg CO2 equivalent	Gg CO2 equivalent	%	%	%	%	%	%	%	%	%
2. Emissions which are not CO2 emissions from Fuel Combustion												
Key Sources												
2F 2. Industrial Proc. F. Consumption of Halocarbons and SF6	HFC	0.00	6.64			16.0	0.468	0.0301	0.0301	0.34	0.48	0.59
4A 4. Agriculture A. Enteric Fermentation	CH4	10.42	10.45			18.4	0.844	-0.0012	0.0474	-0.02	0.43	0.43
4D1 4. Agriculture D. Agricultural Soils; Direct Soil Emissions	N2O	5.45	5.24			72.0	1.659	-0.0017	0.0237	-0.12	0.68	0.69
4D3 4. Agriculture D. Agricultural Soils; Indirect Emissions	N2O	2.72	2.47			156.9	1.707	-0.0015	0.0112	-0.23	0.50	0.55
Non Key Sources												
Rest of sources	all	8.75	9.67	16.9	16.9	23.9	1.017	0.0030	0.0438	0.05	1.05	1.05
Total other Key Sources and rest of sources		27.34	34.47									
Total Uncertainties from Non-CO2 emissions from Fuel Combustion and Other Key Sources					Overall uncertainty in the year (%)		2.76				Trend uncertainty (%)	1.56

A	B	C	D	E	F	G	H	I	J	K	L	M
		Gg CO2 equivalent	Gg CO2 equivalent									
3. Total without LULUCF (combined uncertainty of 1. and 2.)												
Total Emissions	all	228.87	233.17									
Total Uncertainties					Overall uncertainty in the year (%)		**6.45**				Trend uncertainty (%)	**8.43**

Table 1-8 Further information on the Tier 1 uncertainty calculation and reporting for sources in Liechtenstein, 2010 (continued).

Table 6.1 (CONTINUED)
Tier 1 Uncertainty Calculation and Reporting

A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category	Gas	Base year emissions 1990	Current Year 2010 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emission in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO2 eq	Gg CO2 eq	%	%	%	%	%	%	%	%	%
4. LULUCF												
Key Sources												
5A1 5. LULUCF A. Forest Land 1. Forest Land remaining Fore	CO2	-18.64	-18.48	5.0	36.0	36.3	-2.957	0.0032	-0.0838	0.12	-0.59	0.60
5B1 5. LULUCF B. Cropland 1. Cropland remaining Croplan	CO2	4.33	4.46	30.0	25.0	39.1	0.767	0.0000	0.0202	0.00	0.86	0.86
5C1 5. LULUCF C. Grassland 1. Grassland remaining Grassl	CO2	2.13	1.70	20.0	50.0	53.9	0.403	-0.0022	0.0077	-0.11	0.22	0.24
5E2 5. LULUCF E. Settlements 2. Land converted to Settleme	CO2	3.30	3.29	20.0	50.0	53.9	0.780	-0.0005	0.0149	-0.02	0.42	0.42
Non Key Sources												
5A1 5. LULUCF A. Forest Land 1. Forest Land remaining Fore	CH4	0.00	0.00	10.0	70.0	70.7	0.000	0.0000	0.0000	0.00	0.00	0.00
5A1 5. LULUCF A. Forest Land 1. Forest Land remaining Fore	N2O	0.00	0.00	10.0	70.0	70.7	0.000	0.0000	0.0000	0.00	0.00	0.00
5A2 5. LULUCF A. Forest Land 2. Land converted to Forest La	CO2	-0.10	-0.07	20.0	36.0	41.2	-0.012	0.0002	-0.0003	0.01	-0.01	0.01
5B2 5. LULUCF B. Cropland 2. Land converted to Cropland	CO2	0.11	0.08	20.0	50.0	53.9	0.019	-0.0002	0.0004	-0.01	0.01	0.01
5B2 5. LULUCF B. Cropland 2. Land converted to Cropland	N2O	0.00	0.00	6.0	90.0	90.2	0.002	0.0000	0.0000	0.00	0.00	0.00
5C2 5. LULUCF C. Grassland 2. Land converted to Grasslan	CO2	0.01	1.69	20.0	50.0	53.9	0.401	0.0076	0.0077	0.38	0.22	0.44
5D1 5. LULUCF D. Wetlands 1. Wetlands remaining Wetlan	CO2	0.00	0.00	25.0	50.0	55.9	0.000	0.0000	0.0000	0.00	0.00	0.00
5D2 5. LULUCF D. Wetlands 2. Land converted to Wetlands	CO2	0.16	0.13	25.0	50.0	55.9	0.032	-0.0001	0.0006	-0.01	0.02	0.02
5E1 5. LULUCF E. Settlements 1. Settlements remaining Settl	CO2	0.05	0.04	20.0	50.0	53.9	0.010	-0.0001	0.0002	0.00	0.01	0.01
5F2 5. LULUCF F. Other Land 2. Land converted to Other Lar	CO2	0.44	1.15	20.0	50.0	53.9	0.272	0.0032	0.0052	0.16	0.15	0.22
Total LULUCF emissions	all gases	-8.22	-6.00									
Total Uncertainties					**Overall uncertainty in the year (%)**		**3.22**				**Trend uncertainty (%)**	**1.26**

A	B	C	D				H					M
		Gg CO2 eq	Gg CO2 eq									
5. Total with LULUCF (combined uncertainty of 3. and 5.)												
Total Emissions	all gases	220.66	227.17									
Total Uncertainties					**Overall uncertainty in the year (%)**		**7.20**				**Trend uncertainty (%)**	**8.52**

Table 1-9 Further information on the Tier 1 uncertainty calculation and reporting for sources in Liechtenstein, 2010 (continued).

A (continued)				B	N	O	P	Q
IPCC Source category				Gas	Emission factor quality indicator IPCC **D**efault, **M**easurement based, national **R**eferenced data	Activity data quality indicator IPCC **D**efault, **M**easurement based, national **R**eferenced data	Expert judgement reference numbers	Reference to section in NIR
1A	1. Energy	A. Fuel Combustion	Gaseous fuels	CO2	M	D		Section 3.2.6
1A	1. Energy	A. Fuel Combustion	Gas oil and LPG	CO2	M	R		Section 3.2.6
1A	1. Energy	A. Fuel Combustion	Gasoline	CO2	M	R		Section 3.2.6
1A	1. Energy	A. Fuel Combustion	Diesel	CO2	M	R		Section 3.2.6
1A	1. Energy	A. Fuel Combustion	Jet Kerosene	CO2	M	R		Section 3.2.6
1A	1. Energy	A. Fuel Combustion	Solid fuels	CO2	D	D, R		Section 3.2.6
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6		HFC	R	R		Section 4.7.2
4A	4. Agriculture	A. Enteric Fermentation		CH4	R	R		Section 6.2.3
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions		N2O	D	R		Section 6.5.3
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		N2O	D	D		Section 6.5.3
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Fores	CO2	R	R		Section 7.3.3
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Croplan	CO2	R	R		Section 7.4.3
5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassla	CO2	R	R		Section 7.5.3
5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland	CO2	R	R		Section 7.5.3
5D2	5. LULUCF	D. Wetlands	2. Land converted to Wetlands	CO2	R	R		Section 7.6.3
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlemen	CO2	R	R		Section 7.7.3
	Rest of sources			All	R	R		Exp. est.

1.7.1.4 Results of Tier 2 Uncertainty Evaluation (Monte Carlo)

A Tier 2 uncertainty analysis for Liechtenstein's GHG Inventory was carried out for the inventory submitted in 2009 (OEP 2009a) and contained a level uncertainty for 2007 and a trend uncertainty for the period 1990-2007**. For the inventory year 2010 (i.e. the current submission) the Monte Carlo simulation has not been updated**. This analysis will be conducted again for the submission 2014.

The main results for 2007 (must not be compared with the Tier 1 results for 2010 above) were

- The total level uncertainty of the 2007 Liechtenstein emissions is **6,05%** of the total GHG emissions excluding LULUCF. The 95% confidence interval is almost symmetric and lies between **94.0% and 106.1%** of the total GHG emissions.
- The change in total emissions between 1990 and 2007 is +6.1%. With a probability of 95%, the change lies within the range **of -2.7% to +15.0%, corresponding to a trend uncertainty of 8.9%.**
- Assumptions and further results of Monte Carlo simulation are shown in Annex 7)

1.7.1.5 Comparison of Tier 1 and Tier 2 Results

Since no Tier 2 analysis was carried out for the GHG inventory 2010, there is no comparison for the number 2010. Note that a comparison was carried out for the GHG inventory 2007. The results of the comparison are described in Annex A7.2.

1.7.2 KP-LULUCF Inventory

Uncertainty of Afforestation is 26.6% while uncertainty of Deforestation is 44.7%. Combined level uncertainty of the total KP-LULUCF Inventory is 24.6% (see Chapter 11.3.1.5 for details of the calculation). Thus, with a probability of 95%, the KP-LULUCF sink lies between 2.35 and 3.88 Gg CO_2.

1.8 Completeness Assessment

1.8.1 GHG Inventory

Liechtenstein's current GHG inventory is complete for all Kyoto gases.

1.8.2 KP-LULUCF Inventory

Liechtenstein's current KP-LULUCF Inventory is complete.

2 Trends in Greenhouse Gas Emissions and Removals

This chapter gives an overview of Liechtenstein's GHG emissions and removals as well as their trends in the period 1990–2010.

2.1 Aggregated Greenhouse Gas Emissions 2010

In 2010, Liechtenstein emitted 233.17 Gg (kilotonnes) CO_2 equivalent, or 6.6 tonnes CO_2 equivalent per capita (CO_2 only: 5.6 tonnes per capita) to the atmosphere not including emissions and removals from Land Use, Land-Use Change and Forestry (LULUCF). The largest contributor gas is CO_2, and the most important sources of emissions are fuel combustion activities in the Energy sector. Table 2-1 shows the emissions for individual gases and sectors in Liechtenstein for the year 2010. Fuel combustion within the Energy sector was by far the largest source of emissions of CO_2 in 2010. Emissions of CH_4 and N_2O originated mainly from the sector Agriculture, and the synthetic gas emissions stemmed by definition from the sector Industrial Processes.

Table 2-1 Summary of Liechtenstein's GHG emissions by gas and sector in CO_2 equivalent (Gg), 2010. (Numbers may not add to totals due to rounding.)

Emissions 2010	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
1 Energy	198.7	2.0	0.9				**201.6**
2 Industrial Processes	NO	NO	NO	6.6	0.1	0.0	**6.7**
3 Solvent and other Product Use	0.3		0.3				**0.5**
4 Agriculture		12.4	10.1				**22.6**
6 Waste	0.0	0.7	1.0				**1.7**
Total (excluding LULUCF)	**199.0**	**15.1**	**12.3**	**6.6**	**0.1**	**0.0**	**233.2**
5 LULUCF	-6.0	NO	0.0				**-6.0**
Total (including LULUCF)	193.0	15.1	12.3	6.6	0.1	0.0	**227.2**
International Bunkers	*0.8*	*0.0*	*0.0*				***0.8***

A breakdown of Liechtenstein's total emissions by gas is shown in Figure 2-1 below. Figure 2-2 is a bar chart of contributions to GHG emissions by gas and sector.

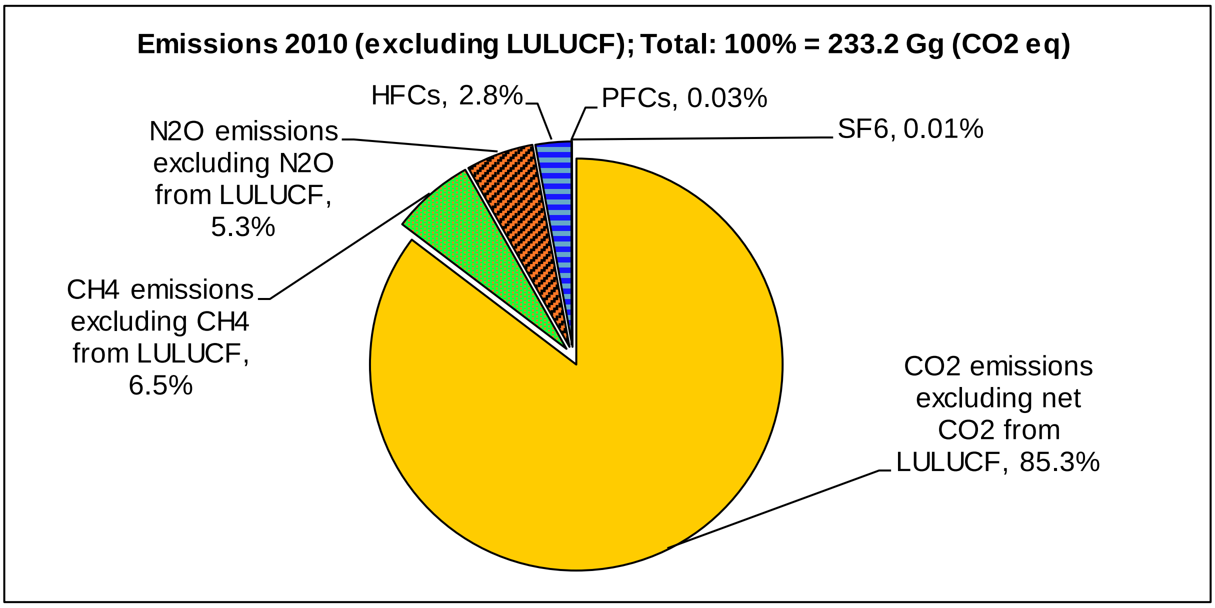


Figure 2-1 Liechtenstein's GHG emissions by gas excluding LULUCF in 2010.

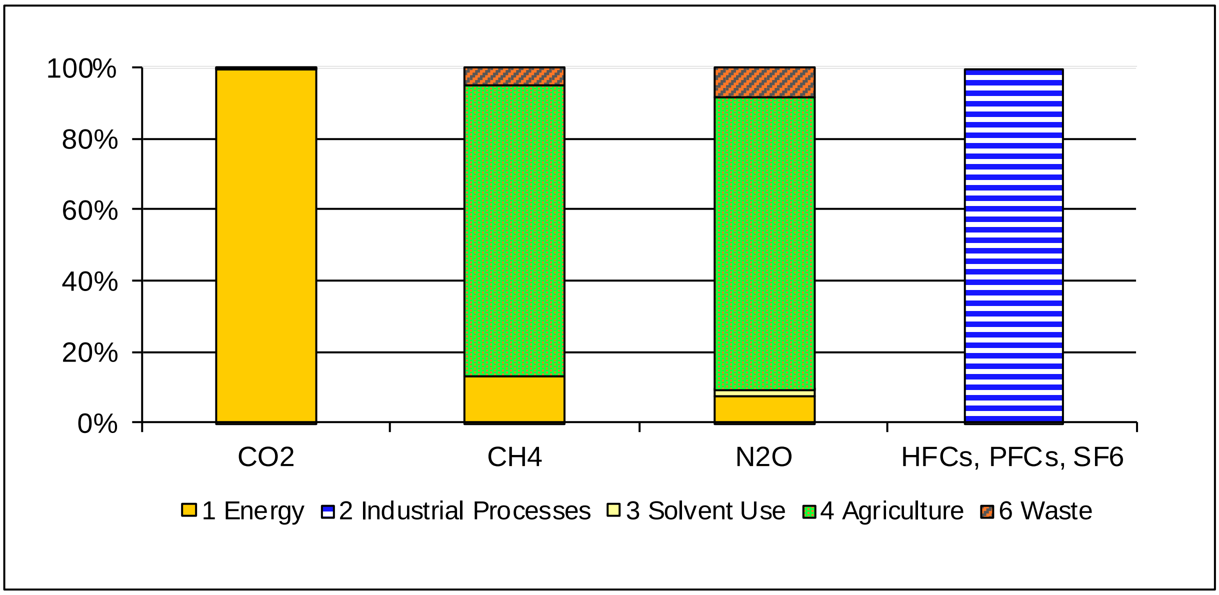


Figure 2-2 Relative contributions of the individual sectors (excluding LULUCF) to GHG emissions in 2010.

2.2 Emission Trends by Gas

Emission trends 1990–2010 by gas are summarised in the Table 2-2 and in Figure 2-3.

Table 2-2 Summary of Liechtenstein's GHG emissions in CO_2 equivalent (Gg) by gas, 1990–2010. The column on the far right (digits in italics) shows the percentage change in emissions in 2010 as compared to the base year 1990.

Greenhouse Gas Emissions	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	193.4	201.2	202.1	210.5	196.6	200.0	202.2	219.5	230.9	230.1
CO_2 emissions excluding net CO_2 from LULUCF	201.6	209.4	210.4	218.8	205.0	208.4	210.6	223.0	234.4	233.5
CH_4 emissions including CH_4 from LULUCF	14.4	14.3	14.0	13.4	13.5	13.4	13.8	13.6	13.5	13.1
CH_4 emissions excluding CH_4 from LULUCF	14.4	14.3	14.0	13.4	13.5	13.4	13.8	13.6	13.5	13.1
N_2O emissions including N_2O from LULUCF	12.9	13.3	13.2	12.8	12.8	12.8	12.9	12.8	12.7	12.6
N_2O emissions excluding N_2O from LULUCF	12.9	13.3	13.2	12.8	12.8	12.8	12.8	12.7	12.6	12.4
HFCs	0.0	0.0	0.0	0.1	0.1	0.4	0.7	1.0	1.4	1.8
PFCs	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0	0.0
SF_6	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0	0.0	0.0	0.0
Total (including LULUCF)	**220.7**	**228.7**	**229.3**	**236.8**	**223.0**	**226.6**	**229.6**	**246.9**	**258.5**	**257.6**
Total (excluding LULUCF)	**228.9**	**237.0**	**237.6**	**245.1**	**231.4**	**235.0**	**237.9**	**250.3**	**261.9**	**260.9**

Greenhouse Gas Emissions	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	***1990-2010***
	CO_2 equivalent (Gg)											*%*
CO_2 emissions including net CO_2 from LULUCF	223.4	221.5	226.5	233.4	233.6	233.4	235.0	204.3	223.3	207.7	193.0	*-0.2*
CO_2 emissions excluding net CO_2 from LULUCF	226.8	224.9	229.9	239.4	239.6	239.4	241.1	210.4	229.4	213.7	199.0	*-1.3*
CH_4 emissions including CH_4 from LULUCF	13.0	13.6	13.9	14.0	14.1	14.7	15.2	15.6	15.8	15.6	15.1	*5.1*
CH_4 emissions excluding CH_4 from LULUCF	13.0	13.6	13.9	14.0	14.1	14.7	15.2	15.6	15.8	15.6	15.1	*5.1*
N_2O emissions including N_2O from LULUCF	12.4	12.5	12.5	12.5	12.2	12.4	12.6	12.7	12.7	12.6	12.3	*-4.2*
N_2O emissions excluding N_2O from LULUCF	12.2	12.5	12.5	12.5	12.2	12.4	12.5	12.7	12.7	12.6	12.3	*-4.2*
HFCs	2.3	3.0	3.3	3.8	4.3	4.4	4.4	4.7	5.1	5.3	6.6	---
PFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	---
SF_6	0.1	0.2	0.3	0.3	0.3	0.3	0.1	0.1	0.4	0.1	0.0	---
Total (including LULUCF)	**251.2**	**250.8**	**256.4**	**264.0**	**264.6**	**265.1**	**267.3**	**237.4**	**257.3**	**241.3**	**227.2**	***3.0***
Total (excluding LULUCF)	**254.5**	**254.2**	**259.8**	**270.0**	**270.6**	**271.1**	**273.3**	**243.5**	**263.5**	**247.3**	**233.2**	***1.9***

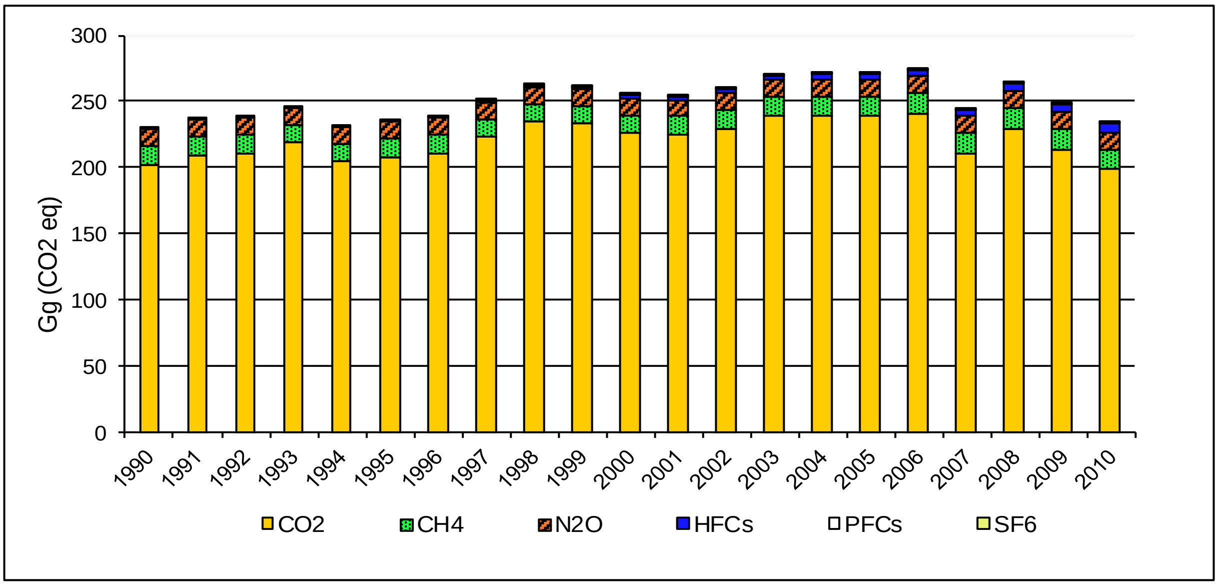


Figure 2-3 Trend of Liechtenstein's greenhouse gas emissions by gases1990–2010. CO_2, CH_4 and N_2O correspond to the respective total emissions excluding LULUCF.

Emission trends for the individual gases are as follows:

- Total emissions excluding LULUCF Removals/Emissions increased from 1990 to 2010 by 1.9%.
- Total emissions including LULUCF increased slightly by 3.0% compared to 1990 levels.
- CO_2 emissions excluding net CO_2 emissions from LULUCF decreased from 1990 to 2010 by 1.3%. It contributes the largest share of emissions, accounting for about 85.3% of the total emissions in 2010. This is the smallest share since 1990 which fluctuated between 85.3% and 89.5% in the period 1990–2010.
- CO_2 emissions excluding net CO_2 emissions from LULUCF indicate a decrease between 2009 and 2010 of -7.1%. Beside the increase in 2007 and 2008 caused by fuel price fluctuations followed by changing stocking behaviour for fuel tanks, since 2006 a negative trend of CO_2 emissions can be observed.
- CH_4 emissions excluding CH_4 from LULUCF decreased by -3% when compared to 2009. However when compared to 1990 emissions, an increase of 5.1% occurred. Its contribution to the total national emissions is 6.5% in 2010, which is slightly higher than in 1990, where the share was 6.3%.
- Compared to 2009 N_2O emissions excluding N_2O from LULUCF have decreased by -2% and by -4.2% when compared to 1990 levels. Its contribution to the total national emissions decreased from 5.6% in 1990 to 5.3% in 2010.
- HFC emissions (mainly from 2F1 Refrigeration and Air Conditioning Equipment) increased due to their role as substitutes for CFCs. SF_6 emissions stem from electrical transformation stations and play a minor role for the total of synthetic gases. PFC emissions are occurring since 1997 and are increasing on a low level. The share of synthetic gases increased from 0.0% (1990) to 2.9% (2010).

2.3 Emission Trends by Sources and Sinks

Table 2-3 shows emission trends for all major source and sink categories. As the largest share of emissions originated from the energy sector, the table also shows the contributions of the energy source categories (1A1-1A5, 1B).

Table 2-3 Summary of Liechtenstein's GHG emissions by source and sink categories in CO_2 equivalent (Gg), 1990–2010. The column on the far right (digits in italics) shows the percent change in emissions in 2010 as compared to the base year 1990.

Source and Sink Categories	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)									
1 Energy	**203.8**	**211.8**	**212.9**	**221.3**	**207.4**	**210.9**	**213.2**	**225.7**	**237.0**	**236.3**
1A1 Energy Industries	0.2	0.8	1.9	1.9	1.8	2.0	2.5	2.5	2.9	2.9
1A2 Manufacturing Industries and Construction	35.3	34.2	34.2	36.0	34.2	34.4	34.3	35.9	38.2	37.6
1A3 Transport	76.7	90.0	89.3	87.2	79.8	81.8	83.1	86.8	86.4	92.1
1A4 Other Sectors	88.9	83.4	84.2	93.3	88.8	89.9	90.3	97.4	105.9	99.8
1A5 Other (Offroad)	2.4	2.9	3.0	2.4	2.3	2.2	2.3	2.6	3.0	3.1
1B Fugitive emissions from oil and natural gas	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7
2 Industrial Processes	**0.0**	**0.0**	**0.0**	**0.1**	**0.1**	**0.4**	**0.7**	**1.0**	**1.4**	**1.8**
3 Solvent and Other Product Use	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.5**	**0.5**	**0.5**
4 Agriculture	**23.0**	**23.1**	**22.6**	**21.6**	**21.7**	**21.6**	**21.9**	**21.5**	**21.3**	**20.6**
6 Waste	**1.6**	**1.5**	**1.5**	**1.5**	**1.6**	**1.5**	**1.6**	**1.6**	**1.6**	**1.6**
Total (excluding LULUCF)	**228.9**	**237.0**	**237.6**	**245.1**	**231.4**	**235.0**	**237.9**	**250.3**	**261.9**	**260.9**
5 Land Use, Land-Use Change and Forestry	-8.2	-8.3	-8.3	-8.3	-8.4	-8.4	-8.4	-3.4	-3.4	-3.2
Total (including LULUCF)	220.7	228.7	229.3	236.8	223.0	226.6	229.6	246.9	258.5	257.6

Source and Sink Categories	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	***1990-2010***
	CO_2 equivalent (Gg)											***%***
1 Energy	**229.7**	**227.6**	**232.5**	**242.0**	**242.0**	**241.9**	**243.6**	**213.0**	**232.0**	**216.3**	**201.6**	***-1.1***
1A1 Energy Industries	2.7	2.9	2.5	2.8	2.9	3.1	2.8	2.5	2.9	2.9	3.2	*1727.1*
1A2 Manufacturing Industries and Construction	34.3	34.6	35.7	38.3	37.4	36.2	37.4	30.9	33.0	23.8	22.4	*-36.6*
1A3 Transport	96.1	92.4	87.8	87.4	85.9	85.4	82.4	86.5	90.9	84.8	80.3	*4.7*
1A4 Other Sectors	92.8	94.4	103.0	109.3	111.9	112.7	116.2	88.6	100.5	100.1	91.2	*2.6*
1A5 Other (Offroad)	3.0	2.6	2.8	3.5	3.1	3.5	3.7	3.4	3.6	3.7	3.5	*46.7*
1B Fugitive emissions from oil and natural gas	0.7	0.8	0.8	0.9	0.9	1.0	1.1	1.1	1.1	1.0	1.1	*230.9*
2 Industrial Processes	**2.4**	**3.2**	**3.5**	**4.0**	**4.6**	**4.7**	**4.5**	**4.8**	**5.5**	**5.5**	**6.7**	***---***
3 Solvent and Other Product Use	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	***-5.0***
4 Agriculture	**20.1**	**21.3**	**21.5**	**21.6**	**21.7**	**22.1**	**23.0**	**23.3**	**23.4**	**23.2**	**22.6**	***-1.8***
6 Waste	**1.7**	**1.6**	**1.7**	**1.8**	**1.8**	**1.9**	**1.8**	**1.9**	**2.0**	**1.8**	**1.7**	***8.5***
Total (excluding LULUCF)	**254.5**	**254.2**	**259.8**	**270.0**	**270.6**	**271.1**	**273.3**	**243.5**	**263.5**	**247.3**	**233.2**	***1.9***
5 Land Use, Land-Use Change and Forestry	-3.2	-3.4	-3.4	-6.0	-6.0	-6.0	-6.1	-6.1	-6.1	-6.0	-6.0	*-27.0*
Total (including LULUCF)	**251.2**	**250.8**	**256.4**	**264.0**	**264.6**	**265.1**	**267.3**	**237.4**	**257.3**	**241.3**	**227.2**	***3.0***

Figure 2-4: Graphical representation of data. For the development of the source categories of sector 1 Energy see Chapter 3.

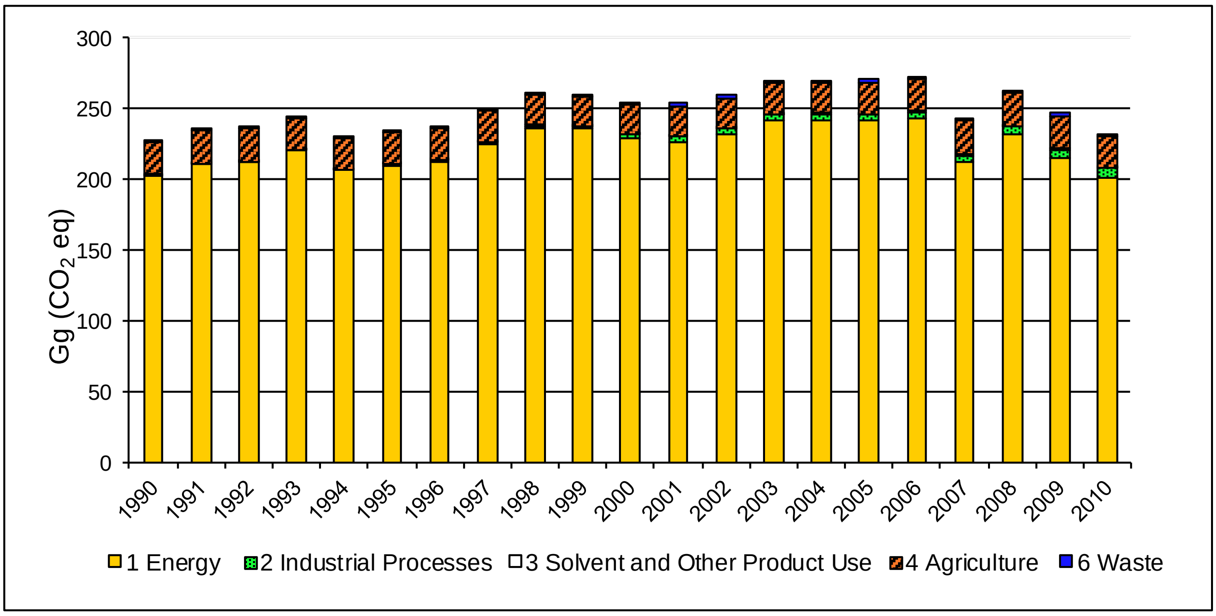


Figure 2-4 Trend of Liechtenstein's greenhouse gas emissions by main source categories in CO_2 equivalent (Gg), 1990–2010 (excl. net CO_2 from LULUCF).

The following emission trends in the sectors are found:

- 1 Energy: 86.5% (excluding LULUCF) of Liechtenstein's GHG emissions stem from the energy sector,which is 0.1% less than in 2009. The source categories show following trends between 1990 and 2010:
- 1A1: The consumption of natural gas in co-generation plants has almost tripled since 1990. Accompanied by an extension of the gas-grid, natural gas has replaced gas oil as the main heating fuel in buildings.
- 1A2: Since 1990 the consumption of gaseous fuels by industries has decreased by -26% and use of liquid fuels decreased even more (-45.6%). However compared to 2009, the gaseous fuels consumption increased in 2010 by 11.0% due to the cold winter 2010.
- 1A3: In line with a general increase of the road-vehicle kilometres of all vehicle categories, the fuel consumption and the emissions have increased since 1990 (7.2%).
- 1A4: Number of Inhabitants have increased by 21.1% whereas employment has increased by 79.4% in the past 20 years. This is reflected in a similar increase of energy consumption and GHG emissions by 19.5% until 2006 with several fluctuations caused by warm and cold winter periods. From 2006 to 2007 a pronounced jump downwards of almost one forth is observed due to high oil gas prices and warm winters. Both influenced the stocking behaviours for private residential fuel tanks and caused higher apparent consumption in 2008, when fuel tanks were refilled. Since 2008 GHG emissions in 1A4 have constantly decreased to 91.1 Gg CO2 eq. in 2010. This negative trend can partly be attributed to the installation of a new district heating pipeline, that was considered stepwise in 2009 and 2010. Furthermore the various emission reduction measures in Liechtenstein, such as the increase of the CO2-tax in 2010, might have resulted in a respective decrease. Also weather conditions are important, as a comparison of the heating degree days in the period 1990–2010 reveals: from 2000 up to 2009 correlation between fuel combustion and winter climatic conditions was relatively high (0.6). Although correlation drops to 0.3 in 2010, weather conditions have been relevant for the residential sector. Consumption from this sector increased due to the coldest winter 2009/10 in 10 years.

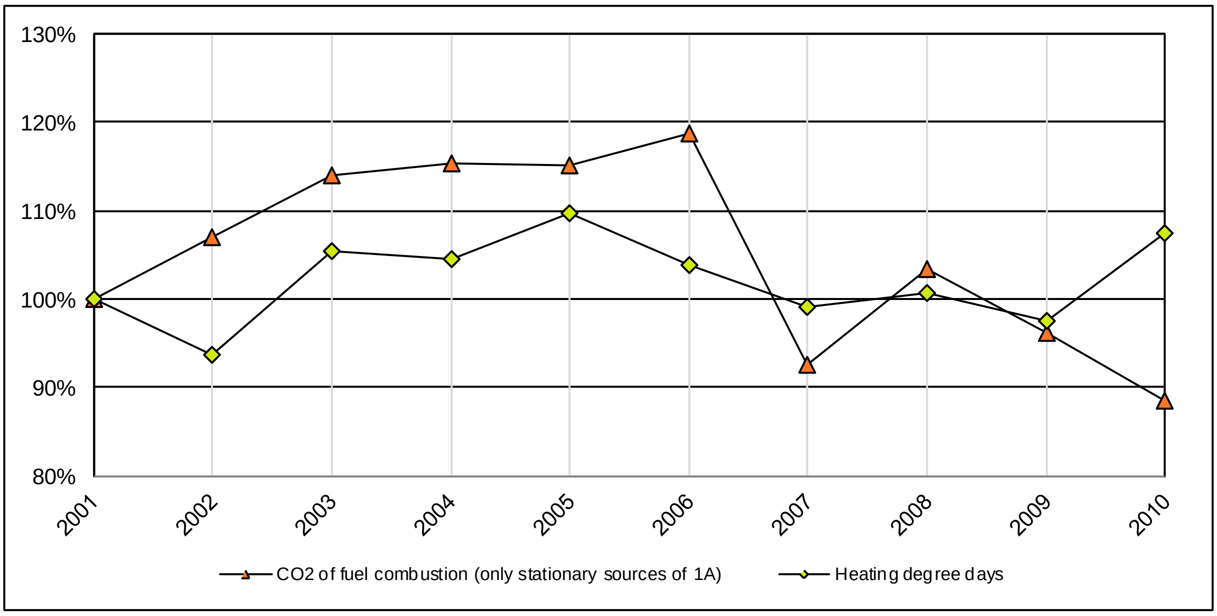


Figure 2-5 Relative trend for CO_2 emissions from 1A Fuel Combustion compared with the number of heating degree days. Jump in 2007 due to high oil gas prices and warm winters.

- 1A5: The emissions reported under this category are all kind of vehicles from construction sites. The general construction activities have increased in Liechtenstein with a subsequent, fluctuating increase of diesel consumption and emissions (46.7% within 1990-2010).
- 1B: In parallel with the built-up of Liechtenstein's gas supply network since 1990, the fugitive emissions have strongly increased over the period 1990-2010 (230.9%).
- 2: Industrial Processes: Due to the lack of heavy industry within the borders of the (small!) state of Liechtenstein, only synthetic gases contribute to sector 2.
- 3: Solvent and other product use: Emissions have decreased in the period 1990-2010 due to reduction measures for NMVOCs resulting from legal restrictions and the introduction of the VOC levy (-5.0%).
- 4 Agriculture: The emissions show a minimum around 2000 due to decreasing and increasing animal numbers. In 2010 the emissions are on more or less the same level as 1990 (decrease of 1.8%).

  5 LULUCF: Figure 2-6 shows the net removals (negative emissions) by sources and sinks from LULUCF categories in Liechtenstein. Increase and decrease of living biomass in forests are the dominant categories. The conversion rates of forest land, which are derived from aerial photographs in four years (1984, 1996, 2002, 2008), differ significantly. They result in a time series similar to a step-like function since they are approximated by constant each period 1984-1996, 1997-2002, 2003-2008. For 2009 and 2010, the mean rate derived from 1984-2008 is used (extrapolation). Other LULCUF categories than forest have a much smaller influence on the net removals.

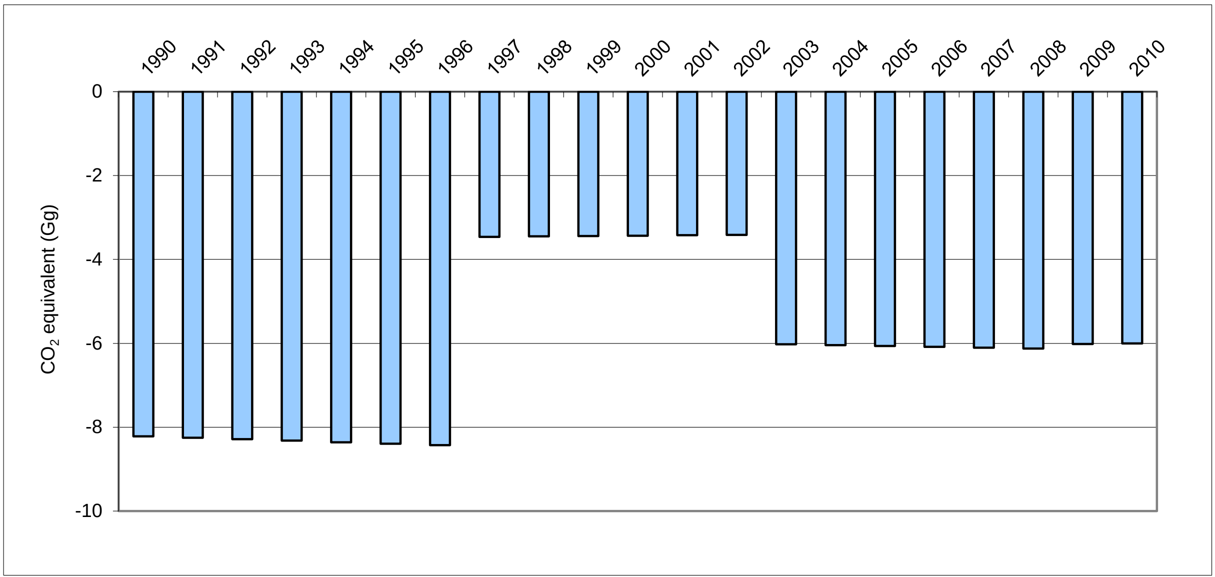


Figure 2-6 Net removals of CO_2 from LULUCF for 1990–2010.

- 6 Waste: In Liechtenstein only few emissions occur from the "Waste" sector, because all municipal solid waste is exported to a Swiss incineration plant. The increasing trend of the emissions compared to 1990 (+8.5%) is determined by increasing composting activities and a slight increase in emissions from waste water handling.

2.4 Emission Trends for Indirect Greenhouse Gases and SO_2

Liechtenstein is member to the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP) and submits data on air pollutants including indirect GHG. For the precursor substances NO_x, CO and NMVOC as well as for the gas SO_2, data from the 2012 submission is shown in Table 2-4 (OEP 2012). Note that the system boundaries for the transportation sector are not the same as under the UNFCCC Reporting since the CLRTAP uses the territorial principle, which restricts the comparability of the two data sets.

Table 2-4: Development of the emissions of NO_X, CO, NMVOC (in t) and SO_X 1990-2010

Source and Sink Categorie	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	t (Mg)									
NO_x	712.0	732.3	724.8	677.2	652.7	632.0	624.9	645.2	672.3	679.3
CO	1'281.8	1'154.5	1'051.0	938.9	874.1	786.3	729.5	702.2	683.1	659.8
NMVOC	875.2	855.5	755.6	717.7	611.7	595.3	485.9	478.8	479.9	475.9
SO_x	71.9	67.0	64.6	62.3	47.8	44.7	43.6	47.5	51.7	49.3

Source and Sink Categorie	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	t (Mg)									
NO_x	661.0	617.3	625.9	676.0	637.5	662.4	666.2	627.9	637.7	634.8
CO	686.3	596.0	579.3	610.0	596.8	606.9	618.9	649.3	646.2	685.8
NMVOC	473.0	403.9	401.5	407.9	402.1	405.3	406.8	403.2	405.7	408.3
SO_x	41.8	38.1	40.7	43.0	36.2	36.3	37.9	27.5	32.1	35.3

Source and Sink Categorie	2010	*'90-'10*
	t (Mg)	*%*
NO_x	*632.4*	*89%*
CO	*631.4*	*49%*
NMVOC	*392.4*	*45%*
SO_x	*30.8*	*43%*

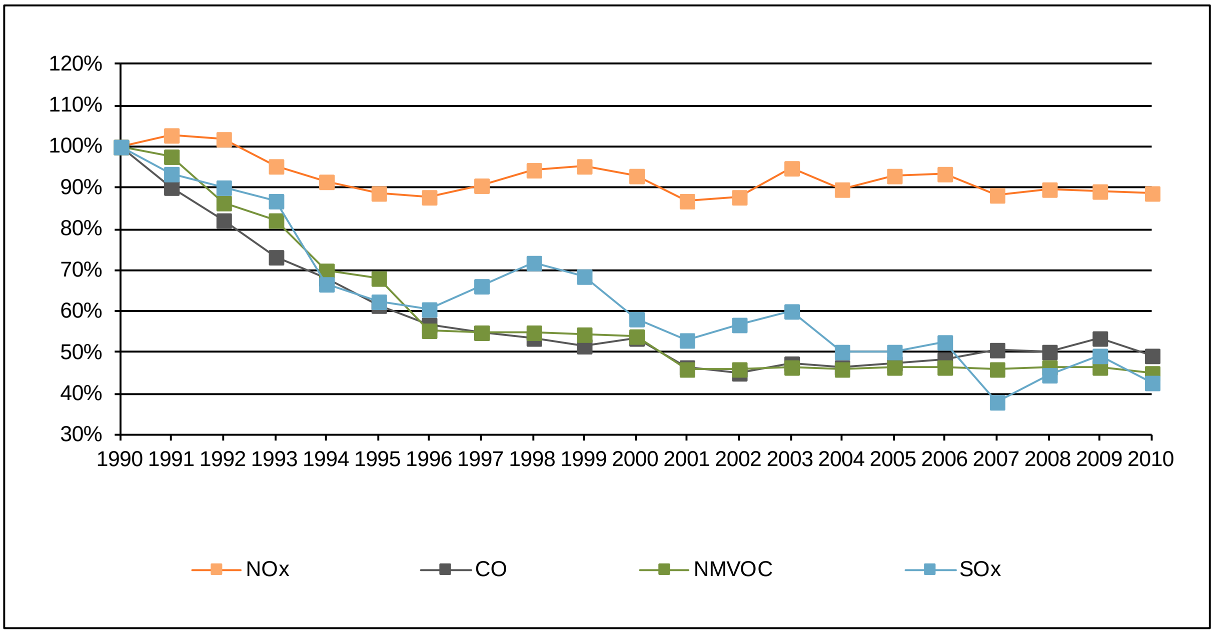


Figure 2-7 Trend of emissions of NOx, CO, NMVOC and SO2 1990-2010.

The complete CLRTAP Inventory data may be found on the internet (see OEP 2012)

2.5 KP-LULUCF Inventory in Aggregate and by Activity, by Gas

The afforested area of ca. 610 ha between 1990-2010 caused removals of 3.26 Gg CO_2 in 2010. Due to deforestation, 0.14 Gg CO_2 were emitted simultaneously in 2010. Afforestation and deforestation resulted in a net removal of 3.11 Gg CO_2 in 2010 (see Table 2-5).

Table 2-5: Summary table afforestation and deforestation. Numbers are taken from Table KP(5-I)A.1.1. and KP(5-I)A.2.

Activity	**Area** (cumulated 1990-2010) kha	**Net CO_2 emisson/removal** 2009 Gg CO_2
Afforestation	0.61	-3.26
Deforestation	0.02	0.14
Total net CO_2 emission/removal		**-3.11**

3 Energy

3.1 Overview

3.1.1 Greenhouse Gas Emissions

This chapter contains information about the greenhouse gas emissions of sector 1 / Energy. In Liechtenstein, the energy sector is the most relevant greenhouse gas source. In 2010, it emitted 201.6 Gg CO_2 equivalents which correspond to 86.4% of total emissions (233.2 Gg, without LULUCF). The emissions of the time period 1990–2010 are depicted in Figure 3-1.

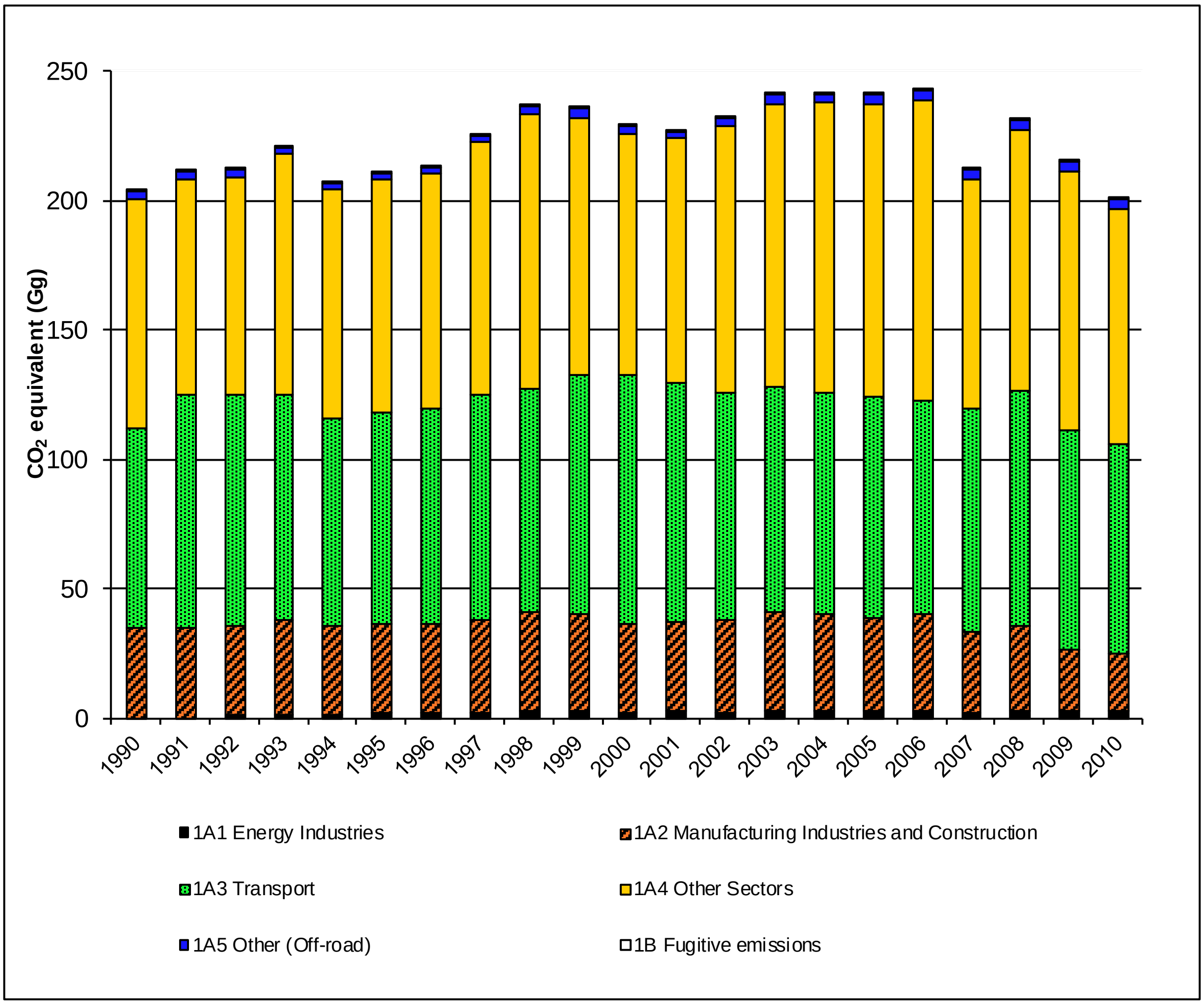


Figure 3-1 Liechtenstein's GHG emissions of the energy sector 1990–2010.

Table 3-1 summarises the emissions of the individual gases 1990–2010. It shows more details of the emissions of sector 1 Energy in 2010. The table includes emissions from international bunkers (aviation), as well as biomass which are both not accounted for in the Kyoto Protocol.

Table 3-1 GHG emissions of source category “1 Energy” in Liechtenstein by gas in CO2 equivalent (Gg), 1990–2010 and the relative increase 1990–2010 (last column).

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CO_2	201.5	209.3	210.3	218.7	204.8	208.2	210.4	222.8	234.1	233.3
CH_4	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3
N_2O	1.1	1.3	1.4	1.5	1.4	1.5	1.6	1.7	1.6	1.6
Sum	**203.8**	**211.8**	**212.9**	**221.3**	**207.4**	**210.9**	**213.2**	**225.7**	**237.0**	**236.3**

Gas	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO_2 equivalent (Gg)									
CO_2	226.5	224.6	229.6	239.1	239.4	239.1	240.8	210.1	229.1	213.4
CH_4	1.5	1.4	1.5	1.6	1.6	1.7	1.8	1.9	2.0	1.9
N_2O	1.7	1.6	1.4	1.4	1.0	1.0	1.0	0.9	1.0	1.0
Sum	**229.7**	**227.6**	**232.5**	**242.0**	**242.0**	**241.9**	**243.6**	**213.0**	**232.0**	**216.3**

Gas	2010	*1990-2010*
		%
CO_2	198.7	*-1.4*
CH_4	2.0	*80.9*
N_2O	0.9	*-18.3*
Sum	**201.6**	***-1.1***

Table 3-2 shows more details of the emissions of sector 1 Energy in 2010. The table includes emissions from international bunkers (aviation) as well as biomass which are both not accounted for in the Kyoto Protocol.

Table 3-2 Summary of sector energy, emissions in 2010 in Gg CO2 equivalent (rounded values).

Emissions 2010	**CO_2**	**CH_4**	**N_2O**	**Total**	
Sources	**CO_2 equivalent (Gg)**				**%**
1 Energy	**198.7**	**2.00**	**0.94**	**201.6**	***100.0***
1A Fuel Combustion	**198.7**	**0.94**	**0.94**	**200.6**	***99.5***
1A1 Energy Industries	3.1	0.03	0.08	**3.2**	***1.6***
1A2 Manufacturing Industries and Construction	22.3	0.03	0.03	**22.4**	***11.1***
1A3 Transport	79.7	0.18	0.47	**80.3**	***39.8***
1A4 Other Sectors	90.1	0.70	0.31	**91.2**	***45.2***
1A5 Other	3.5	0.00	0.04	**3.5**	***1.7***
1B Fugitive Emissions from Fuels	**NA,NO**	**1.06**	**NA,NO**	**1.1**	***0.5***
International Bunkers	0.8	0.00	0.00	**0.8**	***NE,NO***
CO_2 Emissions from Biomass	19.7	**---**	**---**	**19.7**	***---***

The most obvious features of the energy emissions may be characterised as follows:

- Concerning total emissions (CO_2 eq.) from the energy sector, for the first time a decrease of -1.1% in 2010 can be observed when compared to emissions in1990.
- The three source categories 1A2, 1A3 and 1A4 dominate the emissions of 1 Energy and cover together 96.1% of its emissions.
  - 1A2 Manufacturing Industries and Construction contribute 11.1% of the emissions.
  - 1A3 Transport is responsible for 39.8% of the emissions.
  - 1A4 Other Sectors (commercial/institutional, residential) is the largest source with 45.2% of the emissions.
  - 1A1 Energy Industries, 1A5 Other (Off-road) and 1B Fugitive Emissions only play a minor role. In 2010, they cover 1.6%, 1.7% 0.5%, respectively, of the total emissions of 1 Energy.
- The only bunker emissions occurring stem from a helicopter basis in Balzers, Liechtenstein. Only few flights are domestic, most of them are business flights to Switzerland and Austria, producing bunker emissions. The emissions are 0.8 Gg CO_2 eq.
- CO_2 emissions from biomass add up to 19.7 Gg. They include wood burning (heating) and the burning of gas from sewage treatment (heating, power).
- The far most important gas emitted from source category 1 Energy is CO_2. It accounts for 99.0% of the category in 1990 and for 98.5% in 2010.
- In 2010, CH_4 emissions contributed 0.99% to the total emissions of the energy sector. The increasing trend since 1990 (83.3%) is the result of the extended consumption of natural gas and the subsequent increase of fugitive emissions of methane (increase by a factor of 3.5). Additionally the CH_4 emissions of 1A4 have increased by a factor of 3 in the same period. The CH_4 emissions from road transportation have actually decreased by two thirds mainly due to the growing number of gasoline passenger cars with catalytic converters.
- N_2O contributed 0.56% (1990) and 0.46% (2010) to the total emissions of the energy sector. The changes in N_2O emissions may be explained by changes in the emission of passenger cars due to catalytic converters.

The Liechtenstein greenhouse gas inventory identifies 15 key sources (see Chapter 1.5), of which 11 belong to the energy sector. These are depicted in Figure 3-2. Most dominant are the CO_2 emissions from 1A3b Transport (gasoline).

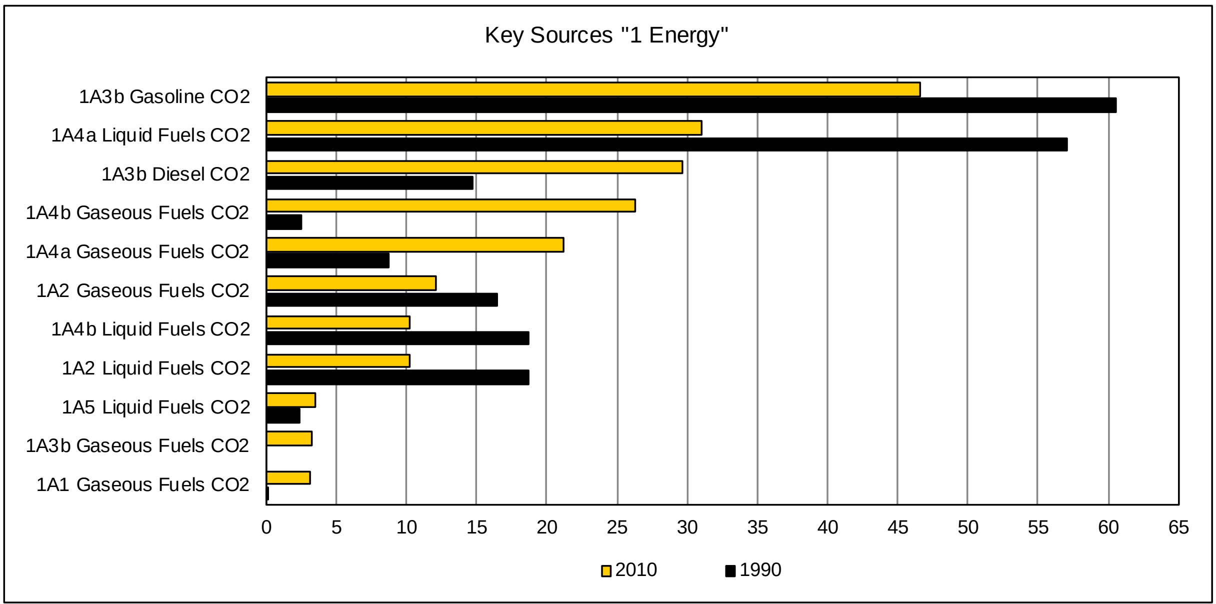


Figure 3-2 Key sources in the Liechtenstein GHG inventory pertaining to the energy sector.

3.1.2 CO_2 Emission Factors and Net Calorific Values

The CO_2 emission factors and the net calorific values (NCV) used for the calculation of the emissions of Sector 1 Energy are shown in Table 3-3.

Table 3-3 CO_2 emission factors and net calorific values (NCV) for fuels. The values are assumed to be constant over the period 1990-2010. The value for natural gas also holds for CNG (compressed natural gas) Data of the fossil fuels are based on SFOE (2001) confirmed by measurements (Intertek 2008). Biofuels data are based on EMIS 2011/ 1A3b.

Fuel	**CO2 Emission Factor 1990-2010**			**Net calorific values (NCV)**		**Density**
	t CO_2 / TJ	t CO_2 / t	t CO_2 / volume	**GJ / t**	**GJ / volume**	**t / volume**
Hard Coal	94.0	2.47	---	26.3	---	---
Gas Oil	73.7	3.14	2.65t / 1000 lt	42.6	36.0 / 1000 lt	0.845 t / 1000 lt
Residual Fuel Oil	77.0	3.17	3.01t / 1000 lt	41.2	39.1 / 1000 lt	0.950 t / 1000 lt
Natural Gas	55.0	2.56	2.00t / 1000 Nm^3	46.5	36.3 / 1000 Nm^3	0.780 t / 1000 Nm^3
Gasoline	73.9	3.14	2.34t / 1000 lt	42.5	31.7 / 1000 lt	0.745 t / 1000 lt
Diesel Oil	73.6	3.15	2.61t / 1000 lt	42.8	35.5 / 1000 lt	0.830 t / 1000 lt
Propane/Butane (LPG)	65.5	---	---	46.0	---	---
Jet Kerosene	73.2	3.15	2.52t / 1000 lt	43.0	34.4 / 1000 lt	0.800 t / 1000 lt
Lignite	104.0	2.09	---	20.1	---	---
Alkylate Gasoline	73.9	3.14	2.34t / 1000 lt	42.5	31.7 / 1000 lt	0.745 t / 1000 lt
Biofuel (vegetable oil)	89.0	3.35	---	37.6	34.6 / 1000 lt	0.92 t / 1000 lt

The NCV are taken from Switzerland (SFOE 2001). An extended measurement campaign, commissioned by the Swiss FOEN and carried out by Intertek (2008) compared measured values with former measurements (EMPA 1999) and showed that the **assumption of constant NCV is widely fulfilled for fuels sold in Switzerland.** The authors write in their report, that only small deviations were found, which are hardly larger than the uncertainties of the measurements[1]. Note that the CO_2 emission factor for natural gas is confirmed by Liechtenstein’s Gas utility LGV (2009).

3.1.3 Energy Statistics (Activity Data)

3.1.3.1 National Energy Statistics and Modifications

In general, the data is taken from Liechtenstein's energy statistics (OS 2011a). A more detailed analysis revealed that the data from the national energy statistics included some inconsistencies and could not simply be copied, but had to be revised in an adequate way as will be explained in the following sections. The revised data is summarised in Table 3-4.

[1] „Im Vergleich mit der letzten grösseren Heizwert-Untersuchung von 1998 (EMPA Prüfbericht Nr. 172853) können nur einige kleine Änderungen beobachtet werden, die aber kaum grösser als die Messungenauigkeit sind“ (Intertek 2008, p. 5). Translated freely into English: “Compared to the last analyses of NCV, only small differences may be observed, which are hardly larger than the uncertainty of the measurement.”

Table 3-4 Time series of Liechtenstein's fuel consumption due to the sales principle, including bunker fuel consumption (kerosene only) and biomass. Data sources: OS (2011a), OEP (2006b, 2006c, 2008a, 2009a, 2010a, 2011a), Rhein Helikopter (2006, 2007, 2008, 2009, 2010, 2011).

Fuel	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	TJ									
Gasoline	819	916	957	947	878	903	909	954	896	940
Diesel	250	339	288	261	230	230	242	252	311	347
Gas Oil	1'272	1'116	1'077	1'189	1'095	1'065	988	1'125	1'208	1'060
Natural Gas	506	614	688	742	754	824	943	914	1'008	1'084
LPG	13.3	8.1	15.5	12.1	9.5	8.1	9.8	7.0	7.2	5.8
Hard Coal	0.97	0.92	1.10	1.00	0.71	0.68	0.50	0.53	0.55	0.29
Kerosene (domestic)	1.03	1.03	1.03	1.03	1.03	1.03	1.04	1.05	1.06	1.07
Sum	**2'862**	**2'995**	**3'027**	**3'154**	**2'969**	**3'032**	**3'093**	**3'253**	**3'431**	**3'439**
1990=100%	100%	105%	106%	110%	104%	106%	108%	114%	120%	120%
Kerosene (bunker)	5.84	5.84	5.84	5.84	5.84	5.84	6.00	6.16	6.33	6.49
Biomass										
Wood	44.7	30.9	44.6	40.5	51.1	37.7	35.0	42.5	47.5	52.2
Sewage gas	15.6	16.3	17.3	17.3	18.7	17.0	18.1	18.4	20.0	21.5
Biofuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum biomass	60.2	47.2	61.8	57.7	69.8	54.7	53.1	60.9	67.5	73.7

Fuel	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	TJ									
Gasoline	1'040	1'007	920	879	851	823	752	756	760	699
Diesel	298	267	284	330	339	364	395	434	488	465
Gas Oil	931	885	1'001	1'061	1'030	986	1'026	608	777	873
Natural Gas	1'067	1'181	1'210	1'294	1'368	1'427	1'454	1'399	1'442	1'139
LPG	5.5	3.9	4.2	4.6	4.1	3.7	5.5	6.1	4.7	4.8
Hard Coal	0.63	0.34	0.32	0.34	0.26	0.24	0.16	0.13	0.11	0.05
Kerosene (domestic)	1.08	1.09	1.14	1.19	0.85	1.15	1.85	1.83	1.79	2.13
Sum	**3'342**	**3'345**	**3'421**	**3'571**	**3'593**	**3'605**	**3'634**	**3'205**	**3'473**	**3'183**
1990=100%	117%	117%	120%	125%	126%	126%	127%	112%	121%	111%
Kerosene (bunker)	6.66	6.82	6.12	6.74	4.82	6.52	10.47	10.36	10.14	12.08
Biomass										
Wood	91.5	56.0	58.6	77.4	84.7	93.8	107.1	142.7	144.0	176.1
Sewage gas	21.7	20.9	20.0	20.7	21.6	20.8	22.5	24.3	25.0	23.7
Biofuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.6	0.1
Sum biomass	113.2	76.9	78.6	98.2	106.3	114.6	129.6	168.1	169.6	199.9

Fuel	**2010**
	TJ
Gasoline	631
Diesel	469
Gas Oil	695
Natural Gas	1'199
LPG	4.0
Hard Coal	0.05
Kerosene (domestic)	1.87
Sum	**2'999**
1990=100%	105%
Kerosene (bunker)	10.59
Biomass	
Wood	189.5
Sewage gas	22.2
Biofuel	0.0
Sum biomass	211.7

The following modifications on the original energy statistics data have been carried out:

Gas oil: The consumption of gas oil in Liechtenstein's energy statistics reflects the amount of gas oil supplied annually to customers in Liechtenstein by oil transport companies. These customers include (i) final consumers as well as (ii) *Liechtenstein's main storage facility* for gas oil, located in Schaan. Gas oil supplied to final consumers in Liechtenstein stems both from sources in Switzerland as well as from Liechtenstein's storage. In order to avoid double counting, the amount of gas oil supplied to the storage facility has to be subtracted from the overall amount of gas oil supplied as provided by the energy statistics. Note that the storage facility was closed in 2008 (see below).

Therefore, data on the amount of gas oil supplied to Liechtenstein's storage facility has been collected from the Cooperative Society for the Storage of Gas Oil in the Principality of Liechtenstein (GHFL 2007, GHFL 2008). Actual consumption of gas oil in Liechtenstein has been calculated based on the total amount supplied according to national energy statistics minus supply to the stock (see Table 3-5).

Table 3-5 Total supply of gas oil as provided by Liechtenstein's energy statistics and fraction of supply that is supplied to Liechtenstein's stock (and may be further supplied to final consumers). Gas oil *consumption 1* is the difference of total supply minus supply to stock:
(*Consumption 1* = *Total supply* - *Supplied to stock*).
This consumption is then corrected for actual density, resulting in *consumption 2*. The latter is then used for Liechtenstein's GHG Inventory. (*Consumption 2* = *Consumption 1 * 0.845 / 0.840*).

Source	**Total supply** Energy Statistics	**Supplied to stock** GHFL 2008	**Consumption 1** Calculated	**Assumed density** OEA-LIE	**Consumption** Calculated	**Actual density** FOEN 2009	**Consumption 2** Calculated	**Consumption** Calculated
Year	Gas oil [t]	Gas oil [t]	Gas oil [t]	Gas oil [t/m3]	Gas oil [m3]	Gas oil [t/m3]	Gas oil [t]	Gas oil [TJ]
1990	35'484	5'813	29'671	0.840	35'323	0.845	29'848	1'272
1991	29'240	3'207	26'033	0.840	30'991	0.845	26'188	1'116
1992	26'083	961	25'122	0.840	29'907	0.845	25'271	1'077
1993	28'531	792	27'739	0.840	33'023	0.845	27'904	1'189
1994	26'931	1'380	25'551	0.840	30'418	0.845	25'704	1'095
1995	25'004	159	24'845	0.840	29'578	0.845	24'993	1'065
1996	23'053	0	23'053	0.840	27'444	0.845	23'190	988
1997	26'443	200	26'243	0.840	31'241	0.845	26'399	1'125
1998	28'701	520	28'181	0.840	33'549	0.845	28'349	1'208
1999	24'774	45	24'729	0.840	29'439	0.845	24'876	1'060
2000	21'931	216	21'715	0.840	25'851	0.845	21'844	931
2001	21'098	435	20'663	0.840	24'599	0.845	20'786	885
2002	24'218	859	23'359	0.840	27'808	0.845	23'498	1'001
2003	24'871	116	24'755	0.840	29'471	0.845	24'903	1'061
2004	24'036	0	24'036	0.840	28'614	0.845	24'179	1'030
2005	23'100	98	23'002	0.840	27'383	0.845	23'139	986
2006	24'231	278	23'953	0.840	28'516	0.845	24'096	1'026
2007	14'549	352	14'197	0.840	16'902	0.845	14'282	608
2008	18'120	0	18'120	0.840	21'571	0.845	18'228	777
2009	20'368	0	20'368	0.840	24'248	0.845	20'489	873
2010	16'212	0	16'212	0.840	19'300	0.845	19'186	817

In 2008, the storage facility has been closed down. From 2008 onwards, the amount supplied to the storage facility is therefore zero.

Gas oil supply is measured in volume units (litres, m^3) and later reported to the Office of Environmental Protection in mass units (t). This conversion is made with a (rounded) density of 0.840 t/m^3, whereas the more correct density is 0.845 t/m^3 (FOEN 2011). Therefore, the *Consumption 1* is corrected accordingly, resulting in *Consumption 2*, as is shown in Table 3-5. Using a net calorific value of 42.6 GJ/t (FOEN 2011), the actual consumption in energy units results as used in Liechtenstein’s GHG inventory. See also Table A - 5.

Natural gas: Natural gas consumption as published in the energy statistics (OS 2011a) is based on net natural gas imports. The amount of natural gas that leaks from the distribution network (reported under 1B2b) and is not burned at the final consumer's combustion system, is subtracted from the net imports in order to determine final consumption in 1A.

Gasoline / Diesel oil: Due to the census carried out by the Office of Economic Affairs (OEA), the fuel consumption had large uncertainties. A number of distributors of gasoline and diesel annually report the amount of gasoline and diesel provided to domestic gasoline stations. Since not all distributors are known (they may come from any Swiss place and may differ every year), the census may not provide a complete statistics. Therefore, in 2000, the Office of Environmental Protection started a second census by direct questioning of all public gasoline stations. The results of this new census can be considered a complete overview of all gasoline and diesel oil sold to passenger cars (including also "tank tourism"[2]), but it covers only the years 2000-2010. For the years 1990-1999 (diesel: 1990-2001 see below), data compiled by OEA were collected in their original units (mass and volume units were used) and transformed into energy units by using the following densities and NCV.

Table 3-6 Values used for the entire period 1990-2010 (OEP 2006c, FOEN 2011). See also Table 3-3 and Table A - 5.

Parameter	unit	Gasoline	Diesel oil	Biodiesel
Density	kg/litre	0.745	0.830	0.920
NCV	GJ/t	42.5	42.8	37.6

For **gasoline** consumption, in 1990 the value of the energy statistics is used. For the years 1991-1999, a 3-years-mean is carried out (e.g. 1991: arithmetic mean of 1990, 1991, 1992). From 2000 to 2009, the values of the second census are used. The result of this modification is shown in Table 3-4 in row gasoline (OEP 2011c).

For **diesel oil** the amount sold at gasoline stations does not yet cover the whole amount consumed.

- There are private diesel stations, which are not part of the OEP census of public accessible gasoline stations. The holders of these private stations are mainly transport companies with heavy duty vehicles, construction companies with construction vehicles and farmers with agricultural machinery/vehicles. Because the diesel oil containers are subject to registration, the holders of these private diesel stations are known by the OEP. Based on this registration data, the OEP in 2002 started a further census of the diesel consumption by these private stations (OEP 2006c, OEP 2011c).
- Finally, consumption from the agriculture sector is known by subsequent information channel:
    - Until 2005: Farmers declared their purchase of diesel fuel and claimed refund of the fuel levy at the General Directorate of Swiss Customs, which was the collecting and refunding institution of fuel levies for fuel purchase in Switzerland and Liechtenstein, and which provided the OEP with the information about the amount declared annually by Liechtenstein’s farmers. For simplification reasons, Switzerland has given up the refunding system.
    - Since 2005: The OEP collects the consumption data directly at the farmers by questionnaire. For the first time this was carried out in winter 2007 to collect the consumption data 2005, which was also available from the former method practised by the General Directorate of Swiss Customs. This allowed a quality

[2] Like in Switzerland, gasoline stations sell relevant amounts of gasoline to foreign car owners due to fuel price differences between Liechtenstein/Switzerland (same prices) and Austria, Germany (higher gasoline prices). This amount of fuel is mainly consumed abroad (Therefore called "tank tourism"), but the whole amount must be reported as national under 1A3b Road transportation. For diesel oil, a similar tourism holds but inverse (import), because diesel oil is cheaper in Austria and Germany.

control check. Since the difference was only 1%[3] (OEP 2006c), both methods may be characterised as of equal and very high quality. The census is now being repeated annually.

- The OEP census for diesel oil therefore encompasses three parts: diesel oil of public gasoline stations (in improved census since 2000), diesel oil consumption of private stations (in census since 2002) and diesel oil consumption by farmers (data available for all years since 1990). The sum of these three parts, as available since 2002, is the total of diesel oil consumption.

For diesel oil, in 1990, the value is taken from the energy statistics. For the years 1991-2001, a 3-years-mean is carried out (e.g. 1991: arithmetic mean of 1990, 1991, 1992), because of low data quality. From 2002 to 2010, the values of the OEP census are used, because for these years data of high quality is available. The result of this modification is shown in Table 3-4 in line “diesel”.

Kerosene: The fuel sales at the single helicopter base have been reported in detail (domestic, international/bunker) for 2001, 2002, 2005, 2006, 2007, 2008, 2009, 2010 and less detailed for 1995 (Rhein Helikopter 2006, 2007, 2008, 2009, 2010, 2011). For the other years in the reporting period, adequate assumptions were made (see Section 3.2.6.3).

Bunker (kerosene, civil aviation): See Section 3.2.2.

Biomass: See Section 3.2.5.1.

3.1.3.2 Energy Statistics and Contribution to the IPCC Source Categories

a) Gas oil

No data on the specific contribution of Source Categories 1A2, 1A4a and 1A4b to total gas oil consumption in 1A Fuel Combustion Activities is currently available. Therefore, the following rough estimated shares based on expert judgement are assumed for all years from 1990 to 2010:

Table 3-7 Estimated share of source categories in total consumption of gas oil in 1A Fuel Combustion Activities.

Source category		**Share in consumption of gas oil (1990-2010)**
1A2	Manufaturing Industries and Contruction	20%
1A4a	Other Sectors - Commercial/Institutional	60%
1A4b	Other Sectors - Residential	20%
Total 1A		100%

b) Natural gas

The data on total consumption of natural gas in Liechtenstein is provided by the gas utility (LGV 2011) and published in the national energy statistics (OS 2011a). It refers to the net import.

For the partition of natural gas consumption between the different combustion activities in 1A, only limited data is available. Even though the gas utility publishes statistics of natural gas consumption of different groups of its customers, the definition of these groups is not

[3] Consumption due to General Directorate of Swiss Customs 514'759 litres of diesel oil, due to questionnaire: 520'618 litres. Difference 5859 litres (1.1%). Data source OEP 2007a.

fully in line with IPCC source categories and appears also somewhat arbitrary. The following tentative attribution is used:

Table 3-8 Tentative correspondence between IPCC source categories and categories in Liechtenstein's natural gas (NG) consumption statistics.

IPCC Source Category		Corresponding category in NG statistics	
		(English)	*(German)*
1A1a	Public Electricity and Heat Production	Co-generation	Blockheizkraftwerke
1A2	Manufacturing Industries and Construction	Industry	Industrie
1A3b	Road Transportation	Fuel for transportation	Treibstoff
1A4a	Other Sectors - Commercial/Institutional	Services	Gewerbe/Dienstleistungen und Öffentliche Hand
1A4b	Other Sectors - Residential	Residential/Households	Wohnungen/Haushalt

c) Gasoline

The entire amount of gasoline sold is attributed to 1A3b Road Transportation.

Alkylate gasoline is attributed 20% to 1A4b and 80% to 1A4c. This attribution is based on an expert estimate which takes into account that most of the alkylate gasoline is used in forestry. The amount sold (activity data) is collected by a census in 2008 of about 80% of the selling stations and consumers (OEP 2009b). Data of the year 2010 is then extrapolated for the entire country. To calculate the time series until 1995 when selling of alkylate gasoline in Liechtenstein started, the developing of consumption values of the two biggest consumers were analysed and these trends adapted to the extrapolation (linear) of the total sales in Liechtenstein back to 1996. For 1995, the year in which the selling started, only 50% of the 1996 amount sold, was taken.

d) Diesel oil

The diesel consumption, which stems from three different data sources, is attributed to the source categories according to the following assumptions (private diesel tanks: see section a. National Energy Statistics and Modifications above).

Table 3-9 Data sources for the diesel consumption and its attribution to IPCC source categories for the period 1990-2010 (Acontec 2006).

Shares of diesel sales Data source	**1A3b Road Transportation**	**1A4c Other Sect./Agriculture**	**1A5b Other/Mobile**	**Sum**
Questioning gasoline stations	100%	0%	0%	100%
Diesel "tanks"	70%	0%	30%	100%
"Oberzolldirektion"	0%	100%	0%	100%

Note

Please note that for the Swiss greenhouse gas inventory, the data for source category 1A Fuel Combustion from the Swiss Overall Energy Statistics is corrected for the gasoil consumption in Liechtenstein (FOEN 2011). In the Swiss GHG Inventory, the gasoil consumption in Liechtenstein is subtracted from the fuel consumption from the Swiss Overall Energy Statistics (that includes Liechtenstein's consumption). Therefore, a potential overestimation (underestimation) of fuel consumption in Liechtenstein is fully compensated by a related underestimation (overestimation) of fuel consumption in Switzerland.

3.2 Source Category 1A – Fuel Combustion Activities

3.2.1 Comparison Sectoral Approach- Reference Approach

3.2.1.1 Comparison of Sectoral Approach with Reference Approach

The Reference Approach uses Tier 1 methods for the different source categories of the energy sector, whereas the National (Sectoral) Approach uses specific methods for the different source categories. For the Inventory of the Framework Convention and the Kyoto Protocol the Sectoral Approach is used. The Reference Approach is only used for controlling purposes (quality control).

Due to the close relations with Switzerland, similar economic structures, the same liquid/gaseous fuels and a similar vehicle fleet composition, a large number of emission factors, especially for CO_2, are taken from the Swiss greenhouse gas inventory. The oxidations factor is consequently set to 1.0 due to the following reason: combustion installations in Liechtenstein have very good combustion properties; combined emissions of CO and unburnt VOC lie in the range of only 0.1 to 0.3 percent of CO_2 emissions for oil and gas combustion. Also for coal an oxidation factor of 1.0 was used for conservative reasons and due to the negligible quantity consumed, which results in an emission of 0.00494 Gg CO_2 in 2010.

Conversion factors (TJ/unit) and carbon emission factors (t C /TJ) in CRF table1.A(b) have been taken from Table 3-3 and are therefore identical to the ones used for the Sectoral Approach.

The apparent consumption, the net carbon emissions and the effective CO_2 emissions are calculated for the Reference Approach as prescribed in the CRF tables 1A(b)–1A(d). Data is taken from the energy statistics as described in chapter 3.1.3. The Reference Approach covers the CO_2 emissions of all imported fuels. Since there is no production nor import of primary fuels into Liechtenstein but only imports of secondary fuels, the calculation of the fuel consumption in the Reference Approach leads to the same result as the Sectoral Approach.

The following table and the figure show the differences between the Reference and the Sectoral (National) Approaches 1990–2010. Energy consumption differs between the two approaches by 0.09%, whereas CO_2 emissions show slight differences of maximally 0.04%.

While congruence between Reference and Sectoral Approach for energy consumption is very high, the difference concerning CO_2 is bigger. The most probable explanation for this, is the fact, that a small fraction of the gas consumed is not burnt but lost before in the distribution network. Therefore these emissions are more climate relevant as they are emitted as CH_4 with higher warming potential (21 CO_2 eq) than if burnt and emitted as CO_2. Therefore the Reference Approach where this fact is considered, becomes bigger in comparison to the Sectoral Approach. As the importance of gas is increasing in Liechtenstein also the differences between the two approaches are increasing.

Table 3-10 Differences in energy consumption and CO_2 emissions between the Reference and the Sectoral (National) Approach. The difference is calculated according to [(RA-SA)/SA] 100% with RA = Reference Approach, SA = Sectoral (National) Approach.

Difference between Reference and Sectoral Approach										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	percent (%)									
Energy Consumption	0.02	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05
CO_2 Emissions	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.02

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	percent (%)									
Energy Consumption	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.08	0.08	0.08
CO_2 Emissions	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.03

	2010
	(%)
Energy Consumption	0.09
CO_2 Emissions	0.04

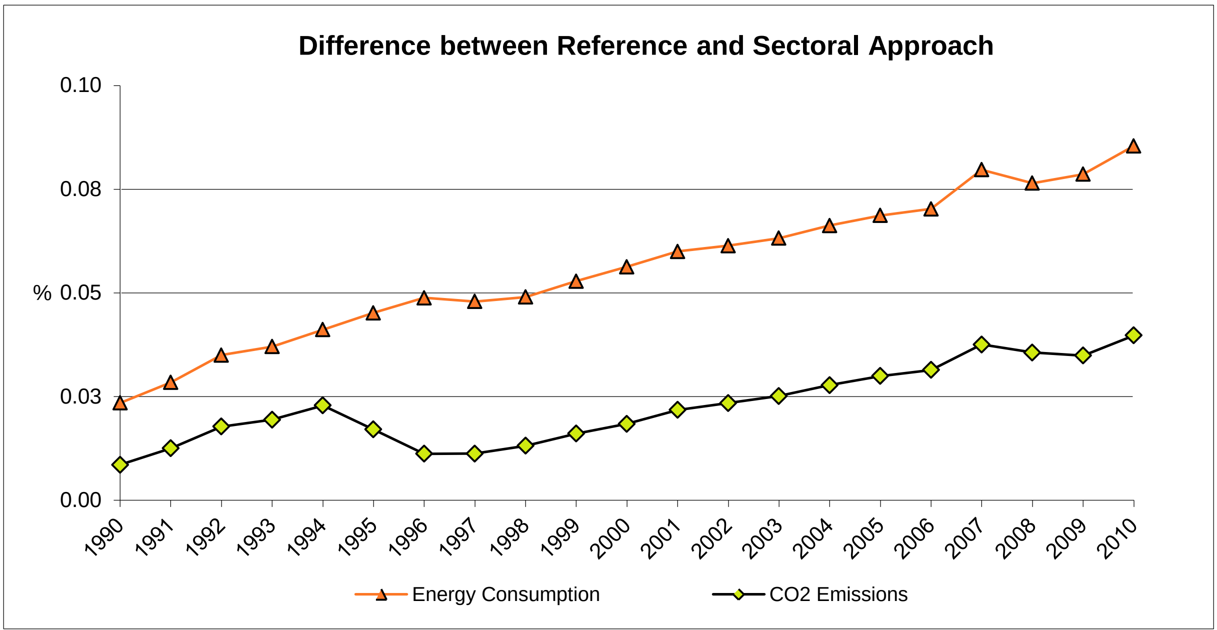


Figure 3-3 Time series for the differences between Reference and Sectoral Approach. Numbers are taken from the table above.

3.2.1.2 Recalculation in the Reference Approach

No recalculation has been carried out for the Reference Approach.

3.2.2 International Bunker Fuels

For Liechtenstein, the only source of international bunker emissions is civil aviation (one helicopter landing site). Total emissions of civil aviation are calculated as described in Section 3.2.6.8 with Tier 1 method. The share of consumption for international flights is provided by the two operating companies of the helicopter landing site Rhein-Helikopter AG and Rotex Helicopter AG for 2001 (84%) and 2002 (86%) (Rhein Helikopter 2006). For all other years, the mean value (85%) is used. Marine bunker emissions are not occurring.

Table 3-11 Kerosene (civil aviation) due to sales principle: International flights (bunker, memo item), domestic flights (reported under 1A3a) and total. Data source: Rhein Helikopter (2006, 2007, 2008, 2009, 2010, 2011).

Kerosene	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	TJ									
international (bunker)	5.84	5.84	5.84	5.84	5.84	5.84	6.00	6.16	6.33	6.49
domestic (1A3a)	1.03	1.03	1.03	1.03	1.03	1.03	1.04	1.05	1.06	1.07
total	6.87	6.87	6.87	6.87	6.87	6.87	7.04	7.21	7.39	7.56
Kerosene	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	TJ									
international (bunker)	6.66	6.82	6.12	6.74	4.82	6.52	10.47	10.36	10.14	12.08
domestic (1A3a)	1.08	1.09	1.14	1.19	0.85	1.15	1.85	1.83	1.79	2.13
total	7.74	7.91	7.26	7.93	5.68	7.67	12.32	12.18	11.93	14.21

Kerosene	2010
	TJ
international (bunker)	10.59
domestic (1A3a)	1.87
total	12.46

3.2.3 Feedstocks and Non-Energy Use of Fuels

Energy data are taken from Liechtenstein's energy statistics (OS 2011a). These statistics account for production, imports, exports, transformation and stock changes. Hence all figures for energy consumption, on which the Swiss GHG inventory is based, correspond to apparent consumption figures.

No bitumen and lubricants are produced in Liechtenstein. There is no production nor import of primary fuels in or into Liechtenstein. Bitumen is imported for road paving. However, use of bitumen does not affect fuel consumption data in Liechtenstein, which are only based on imports of secondary fuels. It is assumed that the fraction of carbon stored in bitumen is 1, meaning that there are no CO_2 emissions from bitumen.

3.2.4 CO_2 Capture from Flue Gases and Subsequent CO_2 Storage if Applicable

Not applicable for Liechtenstein.

3.2.5 Country-Specific Issues

3.2.5.1 CO_2 Emissions from Biomass

A description of the methodology for calculating CO_2 emissions from the combustion of biomass and the consumption of biofuels is included in the relevant Chapters 3.2.6.6 / 3.2.6.8 / 3.2.6.9 (Energy) and 8 (Waste).

3.2.6 Source Category 1A

3.2.6.1 Source Category Description: Energy Industries (1A1)

Key categories 1A1
CO_2 from the combustion of Gaseous Fuels in Energy Industries (1A1) is a key category regarding level and trend.

According to IPCC guidelines, source category 1A1 "Energy Industries" comprises emissions from fuels combusted by fuel extraction and energy producing industries.

In Liechtenstein, fuel extraction is not occurring and 1A1 includes only emissions from the production of heat and/or electricity for sale to the public. Producers in industry generating heat and/or electricity for their own use are included in category 1A2 "Manufacturing Industries and Construction". Waste incineration plants do not exist in Liechtenstein, municipal solid waste is exported to Switzerland for incineration.

Table 3-12 Specification of source category 1A1 "Energy Industries" (AD: activity data; EF: emission factors)

1A1	Source	Specification	Data Source
1A1 a	Public Electricity and Heat Production	This source consists of natural gas or biogas[4] fuelled public co-generation units.	AD: OS 2011a EF: SAEFL 2005
1A1 b	Petroleum Refining	Not occurring	-
1A1 c	Manufacture of Solid Fuels and Other Energy Industries	Not occurring	-

In Liechtenstein, 80% of electricity consumption is imported and 20% is produced domestically. In absolute values, the electricity consumption was around 397 GWh in 2010 compared to around 378 GWh in 2009. This corresponds to an increase of 5% whereas the increase in domestically produced power was with 11.2% higher than the increase in electricity imports of 3.6%. (see Table 3-13).

Table 3-13 Electricity consumption, generation and imports in Liechtenstein in 2010. Data source Energy Statistics 2010 (OS 2011a).

	(MWh)	
Total consumption Liechtenstein 2010	396'580	100%
Power generation in Liechtenstein 2010	78'972	20%
Hydro power	71'881	
Natural gas co-generation	3'469	
Biogas co-generation	797	
Photovoltaic	2'825	
Imports	317'608	80%

Domestic power generation is dominated by hydroelectric power plants (see Figure 3-4). Other power sources are (fossil and bio fuelled) combined heat and power generation, and power generation from photovoltaic plants.

[4] Biogas from sewage sludge in waste water treatment.

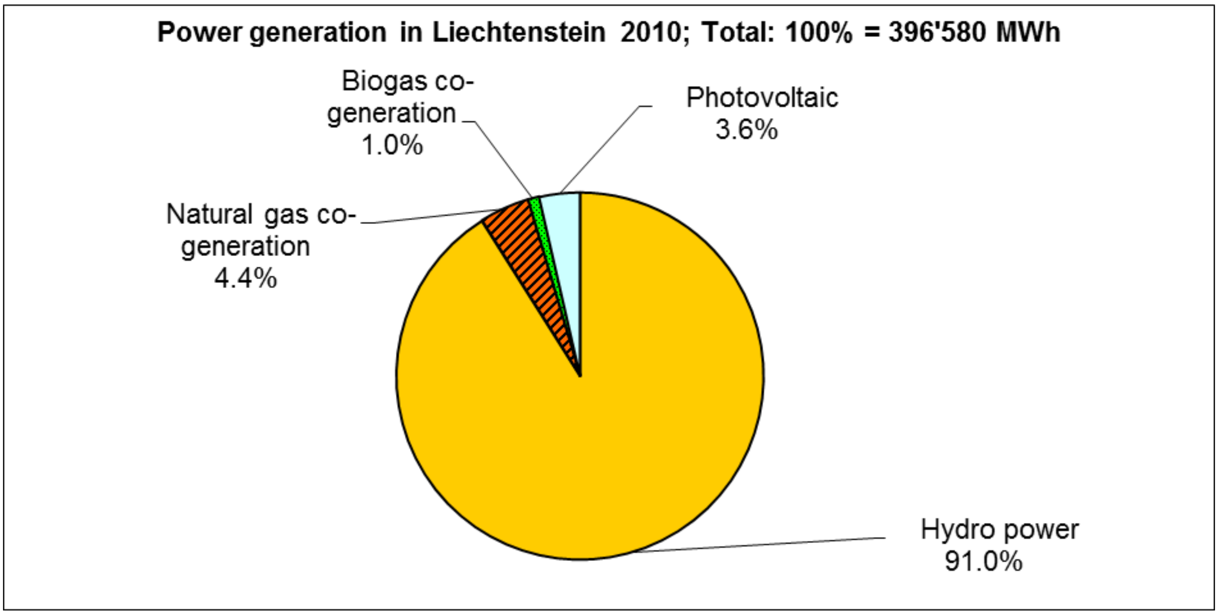


Figure 3-4 Structure of power generation in Liechtenstein 2010. Data source: Energy Statistics 2010 (OS 2011a).

Overall, renewable sources account for 95.6% of domestic power generation in Liechtenstein. Compared to 2009, the electricity produced by photovoltaic plants has increased significantly from 927 MWh to 2’825 MWh and is representing 3.6% of the electricity production in 2010 (while it was only 1.3% in 2009).

3.2.6.2 Source Category Description: Manufacturing Industries and Construction (1A2)

Key categories 1A2
CO_2 from the combustion of Gaseous Fuels and Liquid Fuels in Manufacturing Industries and Construction (1A2) is a key category regarding both level and trend.

The source category 1A2 “Manufacturing Industries and Construction” comprises all emissions from the combustion of fuels in stationary boilers, gas turbines and engines within manufacturing industries and construction. This includes industrial auto-production of heat and electricity. Not included are combustion installations in the commercial/institutional and the residential sector as well as in agriculture/forestry. These are included in category 1A4 (“Other Sectors”).

Iron and Steel, Nonferrous Metals industry, Chemicals and Pulp and Paper production are not occurring in Liechtenstein.

Because data needed for the disaggregation of fuel consumption between the categories 1A2e to 1A2f is not available, all emissions related to Manufacturing Industries and Construction are reported under 1A2f Other.

Table 3-14 Specification of source category 1A2 “Manufacturing Industries and Construction” (AD: activity data; EF: emission factors)

1A2	Source	Specification	Data Source
1A2 a	Iron and Steel	Not occurring.	-
1A2 b	Non-ferrous Metals	Not occurring.	-
1A2 c	Chemicals	Not occurring.	-
1A2 d	Pulp, Paper and Print	Not occurring.	-
1A2 e	Food Processing, Beverages and Tobacco	Included in 1A2f.	-
1A2 f	Other (Combustion Installations in Industries)	Category 1A2 f contains all emissions related to 1A2.	AD: OS 2011a EF: SAEFL 2000a

3.2.6.3 Source Category Description: Transport (1A3)

Key categories 1A3b
CO_2 from the combustion of gasoline (level and trend)
CO_2 from the combustion of diesel (level and trend)
CO_2 from the combustion of gaseous fuels (level and trend)

The source contains road transport and national civil aviation. Civil aviation in fact is only a very small contribution resulting from one only helicopter base in Liechtenstein. Railway is not producing emissions (see below), navigation and other transportation are not occurring. Further off-road transportation is included in category 1A4 Other Sectors (off-road transport in agriculture and forestry) and in 1A5 Other (off-road, e.g. construction).

Table 3-15 Specification of Liechtenstein's source category 1A3 “Transport” (AD: activity data; EF: emission factors).

1A3	Transport	Specification	Data Source
1A3a	Civil Aviation (National)	Helicopters only	AD: Rhein Helikopter AG 2006-2011 Acontec 2006 EF: FOEN 2011, IPCC 1997c
1A3b	Road Transportation	Light and heavy motor vehicles, coaches, two-wheelers	AD: OS 2011a, OEP 2006c, EF: FOEN 2011, IPCC 1997c
1A3c	Railways	Fully electrified system, no electricity infeed, no diesel locomotives, shunting yards	---
1A3d-e	Navigation, military aviation	Not occurring	---

3.2.6.4 Source Category Description: Other Sectors (1A4 – Commercial/Institutional, Residential, Agriculture/ Forestry)

Key categories 1A4a, 1A4b
CO_2 from the combustion of gaseous and liquid fuels in the Commercial/Institutional Sector (1A4a) and in the Residential Sector (1A4b) are key categories regarding both level and trend.

Source category 1A4 "Other sectors" comprises emissions from fuels combusted in commercial and institutional buildings, in households, as well as emissions from fuel combustion for grass drying and off-road machinery in agriculture.

Table 3-16 Specification of source category 1A4 "Other sectors" (AD: activity data; EF: emission factors).

1A4	Source	Specification	Data Source
1A4 a	Commercial/ Institutional	Emission from fuel combustion in commercial and institutional buildings	AD: OS 2011a EF: SAEFL 2000a; SFOE 2001
1A4 b	Residential	Emissions from fuel combustion in households	AD: OS 2011a EF: FOEN 2011; SAEFL 2000a; SFOE 2001
1A4 c	Agriculture/ Forestry/ Fishing	Comprises fuel combustion for agricultural machinery.	AD: OS 2011a EF: SAEFL 2000a; SFOE 2001; INFRAS 2008

3.2.6.5 Source Category Description: Other – Off-road: Construction and Industry (1A5)

Key categories 1A5b
CO_2 from the combustion of liquid fuels in 1A5 Other – Off-road is a key category regarding trend and level.

In Liechtenstein, the source categories are defined according to the next table. The IPCC category structure distinguishes stationary (1A5a) and mobile (1A5b) sources. In Liechtenstein, the main sources are construction and industrial vehicles. All emissions are therefore reported under 1A5b Mobile. 1A5a Stationary sources are not reported. Should some of them occur in reality, their emissions would not be neglected but would appear under 1A5b since the emission of the total amount of fuel sold is included in the modelling.

Table 3-17 Specification of Liechtenstein's source category 1A5b "Other, Mobile" (off-road).

1A5b	Off-road	Specification	Data Source
	Construction	Construction vehicles and machinery	EF: INFRAS 2008 AD: OEP 2011c
	Industry	Industrial off-road vehicles and machinery	

3.2.6.6 Methodological Issues: Energy Industries (1A1)

Key categories 1A1
CO_2 from the combustion of Gaseous Fuels in Energy Industries (1A1) is a key category regarding both level and trend.

In Liechtenstein, Energy Industries (source category 1A1) consists solely of natural gas and biogas fuelled public co-generation units in Public Electricity and Heat Production in 1A1a.

Petroleum Refining (1A1b) and Manufacture of Solid Fuels and Other Energy Industries (1A1c) do not occur.

Methodology Public Electricity and Heat Production (1A1a)

For fuel combustion in Public Electricity and Heat Production (1A1a) a Tier 2 method is used. Aggregated fuel consumption data from the energy statistics is used to calculate emissions. These sources are characterised by rather similar industrial combustion processes and the same emission factors are applied throughout these sources. Emissions of GHG are calculated by multiplying fuel consumption (in TJ) by emission factors.

Emission Factors

The emission factors for CO_2 and CH_4 for co-generation are country specific and representative for engines used in Switzerland and Liechtenstein (lean fuel-air-ratio). They have been taken from Switzerland (SAEFL 2005). For the N_2O emissions the default emission factors from IPCC 1997c have been used.
Biomass: Country specific emission factors for biogas from wastewater treatment plants are taken from SAEFL 2005. The emission factor of biogenic CO_2 has been adapted to take into account CO_2 being present in the biogas as a product of fermentation already prior to combustion.[5]

The following table presents the emission factors used in 1A1a:

Table 3-18 Emission Factors for 1A1a Public Electricity and Heat Production in Energy Industries for all years 1990 - 2010 (public co-generation).

Source/fuel	**CO_2 t/TJ**	**CO_2 bio. t/TJ**	**CH_4 kg/TJ**	**N_2O kg/TJ**
1A1a Public Electricity/Heat				
Natural gas	55	NO	25	0.1
Biomass (biogas from WWTP)	NO	100.5	6	11

Activity Data

Activity data on natural gas consumption (in TJ) for Public Electricity and Heat Production (1A1a) is extracted from the energy statistics (OS 2011a).

[5] The CO_2 emission factor of 100.5 t biogenic CO_2 / TJ biogas is based on the assumption that 35% of the volume of the biogas is CO_2 and 65% CH_4.

Table 3-19 Activity data for natural gas and biomass consumption in 1A1a Public Electricity/Heat Production.

Source/fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A1a Public Electricity/Heat Fuel Consumption											
Natural gas	TJ	2.16	14.04	32.40	33.48	31.32	35.64	44.64	43.56	50.40	50.40
Biomass	TJ	15.57	16.32	17.28	17.28	18.75	16.98	18.12	18.44	19.96	21.49

Source/fuel	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1A1a Public Electricity/Heat Fuel Consumption											
Natural gas	TJ	47.52	50.40	43.20	48.60	50.76	54.00	48.96	44.28	50.04	51.12
Biomass	TJ	21.70	20.87	20.00	20.73	21.64	20.82	22.54	24.26	25.03	23.66

Source/fuel	Unit	2010
1A1a Public Electricity/Heat Fuel Consumption		
Natural gas	TJ	56.16
Biomass	TJ	22.24

The table above documents the increase of Gaseous Fuel consumption by a factor of 26 from 1990 to 2010. This increase is the reason why category 1A1 Gaseous Fuels is a key category regarding trend.

Activity data on biogas consumption from waste water treatment plants are provided by plant operators (for data see section 8.3.1).[6]

3.2.6.7 Methodological Issues: Manufacturing Industries and Construction (1A2)

Key categories 1A2
CO_2 from the combustion of Gaseous Fuels and Liquid Fuels in Manufacturing Industries and Construction (1A2) is a key category regarding both level and trend.

Methodology

For fuel combustion in Manufacturing Industries and Construction (1A2) a Tier 2 method is used.

A top-down method based on aggregated fuel consumption data from the energy statistics is used to calculate CO_2 emissions of 1A2f. All emissions from 1A2 are reported under 1A2f. The sources are characterised by rather similar industrial combustion processes and assumingly homogenous emission factors, where a top-down approach is feasible. Identical emission factors for each fuel type are applied throughout these sources. The unit of emission factors refers to fuel consumption (in TJ).

An oxidation factor of 100% is assumed for all combustion processes and fuels because technical standards for combustion installations in Liechtenstein are relatively high.

Emissions of GHG are calculated by multiplying levels of activity by emission factors.

[6] Activity data for biogas is provided in m^3. A density of 1.2 kg/m^3 and a lower calorific value of 19.2 MJ/kg is used to calculate the energy content.

Emission factors

The emission factors for CO_2 are country specific and are based on measurements and analysis of fuel samples carried out by the Swiss Federal Laboratories for Materials Testing and Research EMPA (carbon emission factor documented in SFOE 2001, Table 45, p. 51).

Emission factors for CH_4 are country specific and based on comprehensive life cycle analysis of industrial boilers in Switzerland, documented in SAEFL 2000a (pp. 14-27). For the N_2O emissions the default emission factors from IPCC 1997c have been used.

The following table presents the emission factors used for the sources in category 1A2f:

Table 3-20 Emission factors for sources in 1A2f for all years 1990 - 2010.

Source/fuel	**CO_2 t/TJ**	**CH_4 kg/TJ**	**N_2O kg/TJ**	**NO_x kg/TJ**
1A2 f Other				
Gas oil	73.7	1.0	0.6	NE
Gas	55.0	6.0	0.1	NE

Activity data

Activity data on fuel consumption (TJ) are based on aggregated fuel consumption data from the energy statistics (see Section 3.1.3).

The resulting disaggregated fuel consumption data for 1990 to 2010 is provided in the table below.

Table 3-21 Activity data fuel consumption in 1A2f Manufacturing Industries and Construction 1990 to 2010

Source	**Unit**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
1A2f Other	TJ	554	545	546	572	546	550	555	574	611	610
Gas oil	TJ	254	223	215	238	219	213	198	225	242	212
Natural gas	TJ	300	322	331	334	327	338	358	349	369	398

Source	**Unit**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
1A2f Other	TJ	559	566	578	622	608	589	609	519	546	372
Gas oil	TJ	186	177	200	212	206	197	205	122	155	175
Natural gas	TJ	373	389	378	410	402	392	404	397	390	197

Source	**Unit**	**2010**
1A2f Other	TJ	359
Gas oil	TJ	139
Natural gas	TJ	220

Table 3-21 documents the net decrease of gas oil consumption by 45% from 1990 to 2010. This decrease is related to the extension of the natural gas-grid in Liechtenstein which replaced gas oil as the main heating fuel in buildings. During the same period, the Natural Gas consumption decreased by 27%. This significant decrease in the natural gas consumption can be explained by the installation of the new district heating pipeline. The increase in natural gas consumption can be explained by the increased heating needs for the winter 2009/2010 as this was a relatively cold winter.

This shift in fuel mix is the reason for CO_2 emissions from Gaseous and Liquid Fuels in category 1A2 being key categories regarding trend.

The gas oil consumption had a sharp decrease in 2007 followed by increases in 2008 and 2009 and another decrease in 2010 which are discussed below under source category 1A4 Other Sectors.

3.2.6.8 Methodological Issues: Transport (1A3)

Key categories 1A3b
CO_2 from the combustion of gasoline (level and trend)
CO_2 from the combustion of diesel (level and trend)
CO_2 from the combustion of gaseous fuels (level and trend)

In Liechtenstein, 1A3 Transport mainly consists of source category 1A3b Road Transportation and a minor contribution of 1A3a Civil Aviation.

a) Aviation (1A3a)

Methodology

The emissions are estimated based on the fuel consumption, flying hours and the fleet composition of Liechtenstein's single helicopter base.

It must be noted, that these emissions are also reported in the Swiss GHG inventory. Since Switzerland and Liechtenstein form a customs union, all imports of kerosene appear in the Swiss overall energy statistics. The Swiss Federal Office of Civil Aviation (FOCA) carries out an extended Tier 3a method to determine the domestic (and bunker) emissions of civil aviation. Within this calculation, all fuel consumption of helicopters is accounted for. The helicopter basis in Balzers/Liechtenstein is included in this modelling scheme. All resulting emissions from helicopters are reported in the Swiss inventory as domestic emissions. The amount of emissions from the Balzers helicopter basis is very small compared to the total of Swiss helicopter emissions. Therefore, Switzerland disclaimed to subtract the small contribution of emissions from its inventory. Nevertheless, for Liechtenstein these emissions are not negligible. They are calculated using a Tier 1 method.

Emissions Factors

Table 3-22 Emission factors used for estimating emissions of helicopters. The values are used for the entire time series 1990-2010.

Emission factors	**CO_2** t/TJ	**CH_4** kg/TJ	**N_2O** kg/TJ
1A3a Civil aviation/ helicopters	73.2	0.5	2.3
data source	FOEN 2011	IPCC 1996	IPCC 1996

Activity Data

The two operating companies of the helicopter base provided data on fuel consumption for 1995, 2001–2010 as well as detailed flying hours, shares of domestic and international flights as well as specific consumption of the helicopter fleet for 2001–2002 (Rhein Helikopter 2006, 2007, 2008, 2009, 2010, 2011). The fleet consists of

Company Rhein-Helikopter AG: Helikopter AS 350 B-3 Ecureuil, 180 litre/hour
Rotex Helicopter AG: Helikopter Kamax K 1200, 320 litres/hour

From the shares of domestic flights in 2001 (14%) and in 2002 (16%), a mean share of 15% was adopted for all other years in the period 1990–2000 and 2003–2010. The consumption

1990–1994, which is not available anymore, is assumed to be constant and equal to 1995. The consumption for 1996–2000 was linearly interpolated between 1995 and 2001.

Table 3-23 Activity data for civil aviation: Kerosene consumption 1990-2010 in TJ (only domestic consumption without international bunker fuel).

Kerosene	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	TJ									
1A3a Civ. Aviation (domestic)	1.03	1.03	1.03	1.03	1.03	1.03	1.04	1.05	1.06	1.07

Kerosene	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	TJ									
1A3a Civ. Aviation (domestic)	1.08	1.09	1.14	1.19	0.85	1.15	1.85	1.83	1.79	2.13

Kerosene	2010
	TJ
1A3a Civ. Aviation (domestic)	1.87

b) Road Transportation (1A3b)

Key categories 1A3b
CO_2 from the combustion of gasoline (level and trend)
CO_2 from the combustion of diesel (level and trend)
CO_2 from the combustion of gaseous fuels (level and trend)

Methodology

The emissions are calculated with a Tier 1 method (top-down) as suggested by IPCC Good Practice Guidance using Swiss emission factors. The CO_2 emission factors are derived from the carbon content of fuels (see Table 3-3).For CH_4 and N_2O, the country specific implied emission factors of the Swiss greenhouse gas inventory are applied. The activity data corresponds to the amounts of gasoline and diesel fuel sold in Liechtenstein (sales principle). These numbers are taken from the national energy statistics modified as mentioned in Chapter 3.1.3. For Liechtenstein, "tank tourism" is a very important feature of the gasoline sales, since the prices in the neighbouring Austria are much higher than in Liechtenstein and Switzerland (which both have the same price due to the Customs Union Treaty). Furthermore a large number of Austrian and German citizens are working in Liechtenstein (numbers for the year 2010: 34’334 registered employees, 17’570 commuters, whereas 48.8% of the commuters are non-Swiss citizens) and buying their gasoline in Liechtenstein (OS 2011b). The method of reporting the fuel sold at all gasoline stations in the country guarantees that indeed the sales principle is applied and not a territorial principle as might be the case by applying a traffic model, which, for Liechtenstein, would considerably underestimate the fuel sold.

Emission Factors

The emission factors for gasoline and diesel oil are adopted from Switzerland:

- CO_2 for fossil gasoline, diesel oil and natural gas: The emission factors are taken from Table 3-3. They are kept constant over the whole time period 1990–2010 as done in Switzerland.
- CO_2 for biofuel: Until 2009 the biofuel produced in Liechtenstein stemmed from one single producer. The fuel was based on recycling of waste vegetable oil consisting of canola mainly. A small fraction of fossil diesel oil was added to the vegetable fuel. The

fossil fraction is contained in the diesel sold and has therefore not to be accounted again (otherwise double counting), whereas the biogenic fraction is not reported under 1A3b but under Memo items “biomass”. An emission factor of 73.6 t/TJ is assumed (FOEN 2011). However, in 2010 the producer stopped its activities and thus in Liechtenstein no production of biofuels occurs anymore.

CH_4, N_2O for gasoline and diesel oil: The implied emission factors of the Swiss CRF Table1.A(a)s3 (rows 1A3b Road Transportation Gasoline / Diesel oil) are used for the period 1990–2009. For the year 2009, a new traffic model with updated implied emission factors was used for the Swiss CRF and thus implied emission factors have changed for Liechtenstein accordingly. The updated values are also incorporated in the CRFs of Liechtenstein, since for the year 2010, the Swiss values 2009 have been used according to the assumptions of Chpt. 1.4.1.2. Note that the regulation for emission concepts of the two countries are identical: Switzerland and Liechtenstein adopt the same limit values for pollutants on the same schedule as the countries of the European Union. The fleet composition of the two countries, the CO_2 emissions of light motor vehicles (passenger cars, light duty vehicles, motorcycles) and the emissions of heavy motor vehicles (heavy duty vehicles, buses, coaches) are similar in Liechtenstein and Switzerland. A quantitative analysis based on the traffic models of Switzerland (INFRAS 2004, Annex A5) and of Liechtenstein (OEP 2002, Table 7, p. 16) shows: The contribution of light motor vehicles to the CO_2 emissions of the total (light and heavy motor vehicles) is 80% in Liechtenstein and 85% in Switzerland. Note that these results are derived on the territorial principle. From the viewpoint of sales principle, both numbers would be higher due to tank tourism, but in Liechtenstein, the increase would be stronger since tank tourism is more pronounced in Liechtenstein than in Switzerland. It may therefore be expected that the two numbers 80% and 85% would even be closer together. This comparison underpins the applicability of Swiss implied emission factors for Liechtenstein. Annual variation in the implied emission factors may reach some percents. But since the emission factors for CO_2 remain unchanged, the deviation of the emission total of source category 1A3b is very small: The recalculation for 2009 shows a difference in CO_2 eq. of -0.02% due to the recalculation of the N_2O and CH_4 emissions factors of 1A3b between latest and previous submission. The emissions 2010 will be recalculated for the submission 2013.

- CH_4, N_2O for biofuel: There are updated implied emission factors available in the Swiss CRF (FOEN 2010). Therefore a recalculation of 2009 data has been carried out with the Swiss implied emission factors for CH_4 and N_2O used for 2007, 2008 and 2009. The factors are assumed to be the same as for fossil diesel fuel.
- CH_4, N_2O for natural gas: Unlike in previous years, there are now implied emission factors available in the Swiss CRF. As for gasoline and diesel, the implied emission factors of the Swiss CRF are used for the period 2001-2010.

Table 3-24 Emission factors for road transport. The values for gasoline and diesel oil are adopted from the Swiss GHG inventory (implied emission factors from CRF Table1.A(a)s3, NIR CH, FOEN 2011). For gaseous fuels, IPCC default values are used (IPCC 1997c). Swiss factors for 2010 are not available yet. For the emission modelling, they are provisionally set equal to the factors 2009. For biofuel (waste vegetable oil), the CO_2 emission factor is given only in addition since it is of biogenic origin.

Gas	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Gasoline																						
CO_2	t/TJ	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9
CH_4	kg/TJ	31.4	28.5	25.8	23.7	21.4	19.7	18.3	17.0	15.7	14.6	13.6	12.8	11.9	11.0	10.5	10.0	9.3	9.00	8.62	8.32	8.32
N_2O	kg/TJ	2.9	3.1	3.3	3.5	3.8	4.0	4.1	4.1	4.0	3.9	3.7	3.48	3.25	2.93	1.80	1.67	1.46	1.38	1.23	1.14	1.14
Diesel																						
CO_2	t/TJ	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH_4	kg/TJ	1.8	1.8	1.8	1.7	1.7	1.6	1.5	1.5	1.4	1.3	1.2	1.1	0.9	0.9	0.8	0.7	0.6	0.55	0.45	0.40	0.40
N_2O	kg/TJ	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.9	0.9	1.0	1.08	1.13	1.17	1.22	1.27	1.41	1.58	1.81	1.95	1.95
Gaseous fuels																						
CO_2	t/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0
CH_4	kg/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
N_2O	kg/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Biofuel																						
CO_2	t/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	73.6	73.6	73.6	NO
CH_4	kg/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.55	0.45	0.40	NO
N_2O	kg/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	1.58	1.81	1.95	NO

The following paragraph gives a couple of explanations to the origin of the Swiss emission factors for road transportation. As described here, a new model by INFRAS (2010) was implemented for the 2011 submission:

Swiss emission factors (excerpt from NIR CH, chpt. 3.2.2.c, FOEN 2011):

"The emission factors for fossil CO_2 and other gases are country specific and based on measurements and analyses of fuel samples (see Table 3-3*). Emission factors for the further gases are country specific derived from "emission functions" which are determined from a compilation of measurements from various European countries with programs using similar driving cycles (legislative as well as standardized real-world cycles, like "Common Artemis Driving Cycle" (CADC). The method has been developed in 1990-1995 and has been extended and updated in 2000, 2004 and 2010. These emission factors are compiled in a so called "Handbook of Emission Factors for Road Transport" (SAEFL 1995, 2004, 2004a, FOEN 2010i, INFRAS 2004, 2004a, 2010). The latest version (3.1) is presented and documented on the website http://www.hbefa.net/. Several reports may be downloaded from there:*

- *Documentation of the general emission factor methodology (INFRAS 2011; forthcoming in German),*
- *Emission Factors for Passenger Cars and Light Duty Vehicles Switzerland, Germany, Austria, Norway and Sweden (INFRAS 2010; in English),*

The resulting emission factors are published on CD ROM ("Handbook of emission factors for Road Transport", INFRAS 2010). The underlying database contains a dynamic fleet compositions model simulating the release of new exhaust technologies and the fading out of old technologies. Corrective factors are provided to account for future technologies. Further details are shown in Annex A3.1.4 of FOEN 2011.

The CO_2 factors are constant over the whole period 1990–2009. The carbon content of the fuels has not changed. However, the increasing portion of biofuels to the fuels is encompassed by the data time series. For the other gases, more or less pronounced decreases of the emission factors occur due to new emission regulations and subsequent new exhaust technologies (mandatory use of catalytic converters for gasoline cars and lower limits for sulphur content in diesel fuels). Early models of catalytic converters have been substantial sources of N_2O, leading to an emission increase until 1998. Recent converter technologies have overcome this problem resulting in a decrease of the (mean) emission factor. The N_2O emission factors vary between 1 and 4 kg/TJ for gasoline, and between 0.5 and 2 kg/TJ, which is higher than the IPCC default values (0.6 kg/TJ). The factors newly *used in Switzerland are taken from Coppert 4 model (EEA 2010). Note that the newly used emission factors are higher than the ones used until the previous submission. In contrast to the N_2O emission factors, the measurement sample for CH_4 emission factors remained the same. However, due to updates in the vehicles fleet composition, the implied emission factors changed eventually."*

It may be added that cold start and evaporative emissions are included in the Swiss modelling scheme.

Activity Data

The amount of gasoline and diesel fuel sold in Liechtenstein serves as the activity data for the calculation of the CO_2 emissions. For diesel, 85.9% of the value for "diesel" in the national statistics of Table 3-4 is consumed in 1A3b Road Transportation, the remaining amount in 1A5b (construction) and 1A4c Other Sectors, agricultural machinery (see also Table 3-30). For gaseous fuels, the amount reported by gasoline stations is used. There is no biofuel production in Liechtenstein anymore.

Table 3-25 Activity data for 1A3b Road Transportation.

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	TJ									
Gasoline	819	916	957	947	878	903	909	954	896	940
Diesel	201	282	231	211	182	184	195	199	253	287
Natural Gas	0	0	0	0	0	0	0	0	0	0
Biofuel	0	0	0	0	0	0	0	0	0	0
Sum	1'020	1'198	1'188	1'159	1'060	1'087	1'104	1'152	1'149	1'226
	100%	118%	116%	114%	104%	107%	108%	113%	113%	120%

Fuel	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	TJ									
Gasoline	1'040	1'007	920	879	851	823	752	756	760	699
Diesel	240	214	229	264	277	298	326	369	420	397
Natural Gas	0	14	31	32	31	32	36	49	54	55
Biofuel	0	0	0	0	0	0	0	1	1	0
Sum	1'279	1'235	1'179	1'175	1'159	1'153	1'114	1'175	1'235	1'152
	125%	121%	116%	115%	114%	113%	109%	115%	121%	113%

Fuel	2010
	TJ
Gasoline	631
Diesel	403
Natural Gas	59
Biofuel	0
Sum	1'093
	107%

The share of gasoline has decreased from 80.3% in 1990 to 57.7% in 2010. In the same period, the consumption of diesel has increased from 19.7% to 36.9%, natural gas from 0% to 5.4%. The consumption of biofuel has only started in 2007 and stopped in 2010, due to halt of production.

In the study OEP (2002) the territorial fuel consumption was estimated based on kilometres travelled. This approach is substantiated by a model which uses input data from transport statistics and traffic counting. The CO_2 emissions were more than 40% lower in the base year and 30% lower in 2004 than the emissions reported in respective GHG inventories. The differences between this result and the statistics of fuel sales are explained by fuelling of Austrian cars due to lower gasoline prices in Liechtenstein. Moreover, the differences show the importance of collecting sales numbers as activity data for Liechtenstein and not using data derived from the territorial principle.

c) Railways (1A3c)

There is a railway line crossing the country, where Austrian and Swiss railways are passing. Liechtenstein has no own railway. The railway line is owned and maintained by the Austrian Federal Railway. The line in Liechtenstein is fully electrified. There are no diesel sales to railway locomotives, therefore there are no emissions occurring, which are relevant for the GHG inventory.

d) Navigation (1A3d)

Navigation is not occurring in Liechtenstein, because there are no lakes, and the river Rhine is not navigable on the territory of Liechtenstein. Therefore, no emissions are occurring for this sector.

3.2.6.9 Methodological Issues: Other Sectors (Commercial, Residential, Agriculture, Forestry; 1A4)

Key categories 1A4a, 1A4b
CO_2 from the combustion of gaseous and liquid fuels in the Commercial/Institutional Sector (1A4a) and in the Residential Sector (1A4b) are key categories regarding both level and trend.

“Other Sectors” (source category 1A4) comprises

- “Commercial/ Institutional” (1A4a)
- “Residential” (1A4b)
- “Agriculture/Forestry/Fisheries” (1A4c)

a) Commercial/ Institutional (1A4a) and Residential (1A4b)

Methodology

For Fuel Combustion in Commercial and Institutional Buildings (1A4a) and in Households (1A4b), a Tier 2 method is used and cross-checked with the country specific estimate on the gas oil consumption based on expert judgement (see sub-section 3.1.3.2a). A top-down method based on aggregated fuel consumption data from the energy statistics is used to calculate emissions. These sources are characterised by rather similar combustion processes and the same emission factors are assumed for 1A4a and 1A4b.

Emissions of GHG are calculated by multiplying levels of activity by emission factors.

An oxidation factor of 100% is assumed for all combustion processes and fuels (see sub-section 3.2.6.7).

Emission Factors

The emission factors for CO_2 are country specific and are based on measurements and analysis of fuel samples carried out by the Swiss Federal Laboratories for Materials Testing and Research EMPA (carbon emission factor documented in SFOE 2001, Table 45, p. 51; net calorific values on p. 61. See also Annex A2.1 of the NIR in hand).

The coal emission factor for CO_2 refers to the emission factor of hard coal in Switzerland (FOEN 2011), where similar conditions prevail.

Emission factors for CH_4 are country specific and are based on comprehensive life cycle analysis of combustion boilers in the residential, commercial institutional and agricultural sectors, documented in SAEFL 2000a (pp. 42-56) and SAEFL 2005. For the N_2O emissions the default emission factors from IPCC 1997c have been used.

The country specific emission factor for CH_4 emissions from Liquefied Petroleum Gas (LPG) is from UBA 2004.

All emission factors for biomass are country specific and are based on SAEFL 2000a (pp. 26ff).

The emission factors for alkylate gasoline are the same as for gasoline, as reported in chapter 3.2.6.8.

Since the fraction of stationary engines in total fuel consumption is rather small, emission factors for combustion boilers are used for all sources and fuels considered.

Table 3-26 presents the emission factors used in 1A4a and 1A4b:

Table 3-26 Emission Factors for 1A4a and 1A4b: Commercial/Institutional and Residential in "Other Sectors" for the year 2010. All emission factors except those for alkylate gasoline are constant for the years 1990 - 2010. Emission factors for alkylate gasoline are the same as for gasoline, as reported in chapter chapter 3.2.6.8.

Source/fuel	**CO_2 t/TJ**	**CO_2 bio. t/TJ**	**CH_4 kg/TJ**	**N_2O kg/TJ**
1A4 a+b Other Sectors: Commercial/Institutional and Residential				
Gas oil	73.7		1.01	0.6
LPG	65.5		2.5	0.1
Alkylate gasoline	73.9		8.32	1.14
Coal	94.0		300	1.6
Natural gas	55.00		6	0.38
Biomass (1A4a)		92	8	1.6
Biomass (1A4b)[7]		92	350	1.6

Activity Data

Activity data on fuel consumption (TJ) are based on aggregated fuel consumption data from the energy statistics. A description of the modifications and the disaggregation of data from energy statistics is provided in Section 3.1.

The resulting disaggregated fuel consumption data from 1990–2010 is provided in Table 3-27.

[7] The CH_4 emission factor of 350 kg/TJ in 1A4b Residential is an average value over emission factors for open fireplaces (700 kg /TJ), old closed stoves (450 kg/TJ), modern closed stoves (130 kg/TJ), and modern closed stoves with ventilation (70 kg/TJ).

Activity data for consumption of alkylate gasoline have been determined by a census carried out by OEP (OEP 2011a) (see also 3.1.3.2). 20% of alkylate gasoline is allocated to households and reported in 1A4b Residential, and 80% of alkylate gasoline is allocated to Agriculture and Forestry and reported in 1A4c.

Table 3-27 Activity data in 1A4a Commercial/Institutional and 1A4b Residential.

Source/Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A4a Commercial/Institutional	TJ	961	892	893	979	943	933	942	1'005	1'100	1'020
Gas oil	TJ	763	669	646	713	657	639	593	675	725	636
LPG	TJ	13.3	8.1	15.5	12.1	9.5	8.1	9.8	7.0	7.2	5.8
Natural gas	TJ	158	196	204	229	246	264	319	298	340	347
Coal	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass	TJ	27	19	27	24	31	23	21	25	29	31
1A4b Residential	TJ	319	319	354	401	390	416	434	467	510	522
Gas oil	TJ	254	223	215	238	219	213	198	225	242	212
Alkylate gasoline	TJ	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
Natural gas	TJ	46	82	120	146	150	188	222	224	248	289
Coal	TJ	1.0	0.9	1.1	1.0	0.7	0.7	0.5	0.5	0.6	0.3
Biomass	TJ	18	12	18	16	20	15	14	17	19	21

Source/Fuel	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1A4a Commercial/Institutional	TJ	976	963	1'057	1'123	1'151	1'168	1'219	955	1'071	1'038
Gas oil	TJ	558	531	601	637	618	591	616	365	466	524
LPG	TJ	5.5	3.9	4.2	4.6	4.1	3.7	5.5	6.1	4.7	4.8
Natural gas	TJ	357	394	417	435	478	516	533	498	514	404
Coal	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass	TJ	55	34	35	46	51	56	64	86	86	106
1A4b Residential	TJ	513	533	565	612	647	667	680	589	647	676
Gas oil	TJ	186	177	200	212	206	197	205	122	155	175
Alkylate gasoline	TJ	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Natural gas	TJ	290	334	341	369	407	432	431	410	434	431
Coal	TJ	0.6	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1
Biomass	TJ	37	22	23	31	34	38	43	57	58	70

Source/Fuel	Unit	2010
1A4a Commercial/Institutional	TJ	921
Gas oil	TJ	417
LPG	TJ	4.0
Natural gas	TJ	386
Coal	TJ	NO
Biomass	TJ	114
1A4b Residential	TJ	692
Gas oil	TJ	139
Alkylate gasoline	TJ	0.1
Natural gas	TJ	477
Coal	TJ	0.1
Biomass	TJ	76

The table above documents the increase of natural gas consumption by a factor of more than two (1A4a) and by a factor more than ten (1A4b) from 1990 to 2010 with the build-up of Liechtenstein's gas supply network. Gas oil consumption decreased by 45% in both categories 1A4a and 1A4b over the same period. This shift in fuel mix is the reason for CO_2 emissions from the use of gaseous and liquid fuels in category 1A4a/b being key categories regarding level and trend.

The significant decrease of 2007, followed again by an increase of gas oil consumption between 2008 and 2009 and a decrease in 2010, is due to two reasons, as explained in chapter 2.3: fluctuation of prices of fossil fuels and warm winters. As stock changes in residential fuel tanks are not taken into account, high prices of fossil fuels therefore led to a smaller apparent consumption of fossil fuels 2007, when stocks were depleted, and higher apparent consumption in 2008, when fuel tanks were refilled. In 2009, the lower prices raised the demand of gas oil and the launch of the CO_2-Tax on 1.1.2010 induced the commercial consumers to refill their fuel tanks at the end of 2009.

b) Agriculture/Forestry (1A4c)

Methodology

For source category 1A4c, a Tier 1 method is used. Emissions stem from fuel combustion in agricultural machinery. Implied emission factors from a Swiss off-road study are used. The activity data is derived from the information provided by the General Directorate of Swiss Customs (refunding institution of fuel levies until 2005) and by OEP census, data 2008 (OEP 2009b). For details, see above in 3.1.3a), paragraph Gasoline/Diesel oil.

Emission Factors

Emission factors for the use of diesel in off-road machinery are country specific and are taken from INFRAS 2008 (diesel engines). Emission factors for alkylate gasoline are shown in Table 3-26.

Activity Data

Off-road machinery: Activity data (diesel consumption) is shown in Table 3-28. In this submission, also the consumption of alkylate gasoline is accounted for (20% in 1A4b and 80% in 1A4c).

Table 3-28 Activity data in 1A4c Agriculture/Forestry.

Fuel	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	TJ									
Alkylate Gasoline	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.4	0.4	0.4
Diesel	18	18	18	17	17	17	16	18	17	19

Fuel	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	TJ									
Alkylate Gasoline	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5
Diesel	17.7	18.4	18.5	19.9	20.5	18.5	19.2	19.9	19.1	19.2

Fuel	**2010**
	TJ
Alkylate Gasoline	0.5
Diesel	18.8

c) Other – Off-road: Construction and Industry (1A5b)

Key source 1A5b
CO_2 from the combustion of liquid fuels in 1A5 Other – Off-road is a key category regarding level.

Methodology

For source category 1A5, a Tier 1 method is used. According to Table 3-9, among private diesel tanks non-agriculture, the amount of 30% of the consumption is attributed to 1A5b Other/Mobile (off-road) activity: Construction vehicles and machinery; Industrial off-road vehicles and machinery. Emission factors are taken from the most recent Swiss off-road study (INFRAS 2008).

Emission Factors

The emission factors are country specific and are based on a query on the Swiss off-road database for construction machinery (INFRAS 2008). They correspond to implied emission factors: The total of emissions of the whole fleet of construction vehicles was divided by the fuel consumption (in TJ). For the application in the Liechtenstein inventory, it is assumed, that the fleet composition is similar to the Swiss fleet composition (vehicle category, size class, age distribution).

Table 3-29 Emission factors used for 1A5b Other – Off-road / mobile sources. Data are based on revised Swiss off-road database (INFRAS 2008).

Gas	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
liquid fuels											
CO_2	t/TJ	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH_4	kg/TJ	0.72	0.73	0.73	0.73	0.73	0.74	0.73	0.73	0.73	0.73
N_2O	kg/TJ	2.98	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99

Gas	unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
liquid fuels											
CO_2	t/TJ	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH_4	kg/TJ	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.71
N_2O	kg/TJ	2.99	2.99	2.99	2.99	2.98	2.98	2.97	2.97	2.97	2.96

Gas	unit	2010
liquid fuels		
CO_2	t/TJ	73.6
CH_4	kg/TJ	0.71
N_2O	kg/TJ	2.96

Activity Data

The activity data includes the consumption of diesel oil as mentioned in the paragraph "Methodology" above and Section 3.1.3a), paragraph Gasoline/Diesel oil.

Table 3-30 Activity data (diesel oil consumption) for 1A5b Other – Off-road / mobile sources.

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	TJ									
Diesel	32.1	38.8	39.6	32.7	30.7	29.7	30.4	34.3	39.8	42.1

Fuel	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	TJ									
Diesel	40.3	34.4	37.2	46.3	41.1	47.5	49.2	45.3	48.3	49.1

Fuel	2010
	TJ
Diesel	47.1

3.2.6.10 Uncertainties and Time-Series Consistency

a) Uncertainties

Uncertainty in aggregated fuel consumption activity data (1A Fuel Combustion)

Liechtenstein and Switzerland form a customs and monetary union governed by a customs treaty. Therefore, no customs statistics exist that would provide reliable data on (liquid and solid) fuels imports into Liechtenstein.

The level of disaggregation that has been chosen for the key category analysis provides a rather fine disaggregation of combustion related CO_2 emissions in Sector 1 Energy. E.g. the key category analysis distinguishes between Emissions from Commercial/Institutional (1A4a), Residential (1A4b), and Agriculture/Forestry (1A4c).

However, the data on fuel consumption originates at the aggregated level of sales data. It is only later disaggregated using simple expert judgement leading to the consumption in different branches (see Section 3.1.3). The analysis of uncertainties for CO_2 emissions from fuel combustion is carried out on the level of aggregated total national emissions (1A) for gaseous, liquid and solid fuels. This to avoid errors that are introduced in the process of disaggregation, but do not apply to the aggregated emissions on the national level. For liquid fuels, the uncertainties have been estimated for four fuel types separately, because methods to determine fuel consumption and associated uncertainties differ for each fuel type (see also Sect. 1.7.1.3 and Sect. 3.1.3).

Details of uncertainty analysis of activity data (fuel consumption) in 1A are based on expert judgements. The dominant contributor to overall uncertainty is liquid fuel consumption. Because customs statistics of imports of oil products do not exist, this data is based on surveys with oil suppliers carried out earlier by OEA and in recent years by OEP. The methodology and completeness of the surveys has been improved over the years. Therefore it is assumed that the uncertainty in activity data for liquid fuels around 1990 is rather high, whereas recent data is of medium uncertainty.

Comparing the different liquid fuels, the uncertainty for gasoline is lowest, because activity data is based on surveys at all filling stations in Liechtenstein and the uncertainty is estimated to be 10%. Diesel consumption is also based on surveys at filling stations, but small unknown quantities may be imported directly from construction companies and farmers, and uncertainty is estimated to be 15%. The uncertainty for gas oil and LPG consumption is estimated to be the highest among liquid fuels, because fuel is provided by direct delivery to homes by several companies, which is more difficult to monitor, and uncertainty is estimated to be 20%. Uncertainty for jet kerosene is estimated to be 15%. The total of kerosene reported may be known more precisely, but the split into domestic and international is quite uncertain.

Uncertainty in CO_2 emission factors in fuel combustion (1A)

Liechtenstein and Switzerland form a customs and monetary union governed by a customs treaty. Therefore, all gas oil is supplied by Swiss suppliers and no taxation accrues at the borders for the import to Liechtenstein. It may therefore be assumed that fuel has the same properties as the fuels sold on the Swiss market. Therefore, the emission factors and their uncertainties have been taken from Switzerland, and are documented in the Swiss NIR (FOEN 2011).

Table 3-31 provides the results of the quantitative Tier 1 analysis (following Good Practice Guidance; IPCC 2000, p.6.13ff) estimating uncertainties of CO_2 emissions from fuel combustion activities.

Table 3-31 Results from Tier 1 uncertainty calculation and reporting for CO_2 emissions in 1A Fuel Combustion.

IPCC GPG Table 6.1
Tier 1 Uncertainty Calculation and Reporting

A				B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category				Gas	Base year emissions 1990	Current Year 2010 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combinded uncertainty as % of total national emission in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
					Input data	Input data	Input data	Input data	Calc/Input						
					Gg CO2 equivalent	Gg CO2 equivalent	%	%	%	%	%	%	%	%	%
1. CO2 emissions from Fuel Combustion															
1A	1. Energy	A. Fuel Combustion	Gaseous fuels	CO2	27.81	65.93	5.0	4.6	6.8	1.972	0.1688	0.2988	0.78	2.11	2.25
1A	1. Energy	A. Fuel Combustion	Gas oil and LPG	CO2	94.58	51.47	20.0	0.61	20.0	4.534	-0.2071	0.2333	-0.13	6.60	6.60
1A	1. Energy	A. Fuel Combustion	Gasoline	CO2	60.53	46.62	10.0	1.36	10.1	2.071	-0.0709	0.2113	-0.10	2.99	2.99
1A	1. Energy	A. Fuel Combustion	Diesel	CO2	18.43	34.53	15.0	0.47	15.0	2.281	0.0704	0.1565	0.03	3.32	3.32
1A	1. Energy	A. Fuel Combustion	Jet Kerosene	CO2	0.08	0.14	15.0	1.16	15.0	0.009	0.0003	0.0006	0.00	0.01	0.01
1A	1. Energy	A. Fuel Combustion	Solid fuels	CO2	0.09	0.00	20.0	5.0	20.6	0.000	-0.0004	0.0000	0.00	0.00	0.00
Total CO2 Emissions Fuel Combustion				CO2	201.53	198.70									
Total Uncertainties CO2 Emissions Fuel Combustion								Overall uncertainty in the year (%)		5.83				Trend uncertainty (%)	8.28

The analysis results in an overall uncertainty of the CO_2 emissions from 1A Fuel Combustion of 5.83% for the year 2010 and in a trend uncertainty for the period 1990 to 2010 of 8.28%.

The overall uncertainty is determined by the rather high activity data uncertainty of liquid fuels.

Qualitative estimate of uncertainties of non-key category emissions in 1A Fuel Combustion

Non-CO_2 emissions in Energy Industries (1A1), Manufacturing Industries and Construction (1A2) and Other Sectors (Commercial, Residential, Agriculture, Forestry; 1A4):
Uncertainty in emissions of non-CO_2 gases is estimated to be medium.

Non-CO_2 emissions in 1A3 and 1A5
Uncertainty in emissions of non-CO_2 gases is estimated to be high.

b) Consistency and Completeness in 1A Fuel Combustion

Consistency:
The method for the calculation of GHG emissions is the same for the years 1990 to 2010; time series is consistent.

Completeness:
The emissions for the full time series 1990–2010 have been calculated and reported. The data on emissions of the six Kyoto gases (CO_2, CH_4, N_2O, HFC, PFC, SF_6) are therefore complete.

3.2.6.11 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2010 and for the changing rates 2009/2010). They are documented in the checklist in Annex 8. Special attention has been focused on the update of the activity data i.e. on the energy sales data. They were checked independently by two NIR authors and by the OEP specialist. In addition, the activity data has been counter-checked with the data in the Energy Statistics of Liechtenstein as well as with the annual report of the Gasdistribution Liechtenstein (LGV).

Road Transportation (1A3b)

The international project for the update of the emission factors for road vehicles is overseen by a group of external and international experts that guarantees an independent quality control. For the update of the modelling of Switzerland's road transport emissions, which has been carried out between 2008 and 2010 and is also used for Liechtenstein, several experts from the federal administration have conducted the project. The results have undergone large plausibility checks and comparisons with earlier estimates.

The emission factors for CH_4 and N_2O used for the modelling of 1A3b Road Transportation are taken from the handbook of emission factors (INFRAS 2010), which is also applied in Germany, Austria, Netherlands and Sweden. The Swiss emission factors for CH_4 and N_2O used in 1A3b were additionally compared with those depicted in the CRF from Germany and a high consistency was found. Possible smal differences might result from a varying fleet composition.

3.2.6.12 Source-Specific Recalculations (incl. changes due to review)

1.A: According to the new Swiss emission factors (FOEN 2011), the implied emission factors in Liechtenstein have been updated. The update affects CH_4 and N_2O emissions of the categories 1A3b Road Transportation, 1A4c Other Sectors, Agriculture/Forestry and 1A5b Other/off-road for the whole time series. The territorial model of road transport in Switzerland has been improved, thus methods, activity data and emission factors have changed. However, emission factors for CO_2 remained unchanged. The fleet composition for the years 2004-2009, which in the former model was based on a projection, has been replaced by statistical data. There were no new measurements of CH_4, thus vehicle segment-specific emission factors did not change. Nevertheless, the implied emission factors for CH_4 have changed due to updated composition of the vehicle fleet. The emission factors of N_2O used so far (which were based on Dutch measurement campaign) have been replaced by the emission factors implemented in Coppert 4 model.

3.2.6.13 Source-Specific Planned Improvements

It is planned to move the emissions from construction and industry from 1A5b to 1A2 in the next submissions.

Currently the amount of Alkylate gasoline sold is based on a census conducted in 2008. In this census about 80% of the selling stations and consumers provided information about the amount consumed. Currently a new census is conducted for the year 2011 that encompasses all consumers of Alkylate gasoline and thus comprehensive data will be available for next submission.

3.3 Source Category 1B – Fugitive Emissions from Fuels and Oil and Natural Gas

3.3.1 Source Category

3.3.1.1 Source Category Description

Source category 1B "Fugitive Emissions from Fuels" is **not a key category.**

Fugitive emissions arise from the production, processing, transmission, storage and use of fuels. According to IPCC guidelines, emissions from flaring at oil and gas production facilities are included while emissions from vehicles are not included in 1B.

Source Category 1B "Fugitive Emissions from Fuels" comprises the following source categories:

- Solid fuels (1B1)
- Oil and Natural Gas (1B2)

a) Solid fuels (1B1)

Coal mining is not occurring in Liechtenstein.

b) Oil and Natural Gas (1B2)

Table 3-32 Specification of source category 1B2 “Fugitive Emissions from Oil and Natural Gas” (AD: activity data; EF: emission factors)

1B2	Source	Specification	Data Source
1B2 a	Oil	Refining of oil is not occurring	-
1B2 b	Natural Gas	Emissions from gas pipelines	AD: LGV 2011 EF: FOEN 2011
1B2 c	Venting / Flaring	Not occurring	-

3.3.2 Methodological Issues

a) Oil and Natural Gas (1B2)

Methodology

For source 1B2b Natural Gas, the emissions of CH_4 leakages from gas pipelines are calculated with a Tier 3 method, adapted from the Swiss NIR (FOEN 2011). The method considers the length, type and pressure of the gas pipelines. The distribution network components (regulators, shut off fittings and gas meters), the losses from maintenance and extension as well as the end user losses are taken into account. NMVOC leakages are not estimated.

Emission factors

The emission factors for gas distribution losses (source 1B2b) depend on the type and pressure of the natural gas pipeline (see Table 3-33; sources cited in FOEN 2011, Battelle 1994, Xinmin 2004). The CH_4-emissions due to gas meters are considered with an emission factor of 5.11$m^3 CH_4$ per gas meter and year.

Table 3-33 CH_4-Emission Factors for 1B2 “Fugitive Emissions from Oil and Natural Gas” in 2010 (Battelle 1994, Xinmin 2004). For HDPE (Polyethylene) 1-5 bar, the first value shows the assumption for 1993 and previous years while the second value (in brackets) shows the value for 2001 and following years. Data between 1993 and 2001 are linearly interpolated between the two values.

1B2 Fugitive Emissions from Oil and Natural Gas	< 100 mbar [m^3/h/km]	1- 5 bar [m^3/h/km]	> 5 bar [m^3/h/km]
Steel cath.	-	-	0.0284
HDPE (Polyethylene)	0.0080	0.0024 (0.00062)	-

Activity data

The activity data such as length and type of pipes in the distribution network for the calculation of methane leaks have been extracted from the annual reports of Liechtenstein's Gas Utility (LGV 2011).

Table 3-34 Activity Data for 1B2 “Fugitive Emissions from Oil and Natural Gas”: length of pipes and number of connections to customers

Source/Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1B2 Fugitive Emissions from Oil and Natural Gas											
Steel cath. > 5 bar	km	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3
HDPE (Polyethylene) < 100 mbar	km	67.0	84.3	96.5	109.0	122.4	135.9	147.6	162.7	179.3	192.0
HDPE (Polyethylene) 1-5 bar	km	28.5	28.5	28.3	28.5	29.2	29.5	29.8	30.0	34.1	35.8
Connections	No.	479	698	890	1'060	1'221	1'398	1'584	1'782	1'984	2'195

Source/Fuel	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1B2 Fugitive Emissions from Oil and Natural Gas											
Steel cath. > 5 bar	km	26.3	26.3	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6
HDPE (Polyethylene) < 100 mbar	km	206.0	218.7	238.5	252.0	264.9	276.3	289.1	297.6	304.6	308.6
HDPE (Polyethylene) 1-5 bar	km	37.3	37.4	36.0	38.9	45.3	45.6	49.3	49.7	50.1	50.8
Connections	No.	2'460	2'657	2'863	3'067	3'271	3'464	3'659	3'801	3'948	4'045

Source/Fuel	Unit	2010
1B2 Fugitive Emissions from Oil and Natural Gas		
Steel cath. > 5 bar	km	26.6
HDPE (Polyethylene) < 100 mbar	km	312.8
HDPE (Polyethylene) 1-5 bar	km	51.0
Connections	No.	4'116

The table above documents the continuous increase of Liechtenstein’s gas supply network since 1990. The number of connections installed have increased by more than factor 8 compared to those from 1990 to 2010.

3.3.3 Uncertainties and Time-Series Consistency

Uncertainty in fugitive CH_4 emissions from natural gas pipelines in 1B2
Following Good Practice Guidance (IPCC 2000: p.2.92) overall uncertainty of bottom-up inventories of fugitive methane losses from gas activities are expected to result in errors of 25-50%. From this a conservative uncertainty of 50% is estimated for Liechtenstein.

The time series is consistent.

3.3.4 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2010 and for the changing rates 2009/2010).

3.3.5 Source-Specific Recalculations

No recalculations have been carried out.

3.3.6 Source-Specific Planned Improvements

The current 1B2 methane emission calculation is based on data on natural gas quality from Switzerland (FOEN 2011).

4 Industrial Processes

4.1 Overview

According to IPCC guidelines, emissions within this sector comprise greenhouse gas emissions as by-products from industrial processes and also emissions of synthetic greenhouse gases during production, use and disposal. Emissions from fuel combustion in industry are reported under sector 1 Energy.

Only few IPCC source categories among the sector Industrial Processes occur in Liechtenstein. Sources in the categories 2B, 2C, 2D, 2E and 2G are not occurring at all. Emissions are reported from categories 2A Mineral Products and 2F Consumption of Halocarbons, Perfluorcarbons and SF_6. HFC emissions are estimated from refrigeration and air conditioning equipment as well as some SF_6 emissions from electrical equipment. The emissions have increased from 1990 to 2010, as shown in Table 4-1

Table 4-1 GHG emissions of source category 2 “Industrial Processes” 1990–2010 by gases. HFC, PFC and SF_6 in CO_2 equivalent (Gg).

Gas	Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	2A Mineral Products	**Gg**									
CO	2A5	0.020	0.020	0.020	0.020	0.020	0.020	0.019	0.019	0.019	0.020
NMVOC	2A6	0.032	0.030	0.028	0.026	0.025	0.023	0.023	0.023	0.023	0.022
	2F Consumption of Halocarbons and SF6	**Gg CO_2 eq**									
HFC	2F1, 2F4	0.00	0.00	0.01	0.05	0.14	0.38	0.66	1.04	1.38	1.81
PFC		NO	NO	NO	NO	NO	NO	NO	NO	0.00	0.00
SF6	2F8	NO	NO	NO	NO	NO	NO	2.4E-04	2.4E-04	2.4E-04	4.8E-03
Sum	**2F**	**0.00**	**0.00**	**0.01**	**0.05**	**0.14**	**0.38**	**0.66**	**1.04**	**1.38**	**1.81**

Gas	Category	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	2A Mineral Products	**Gg**									
CO	2A5	0.020	0.021	0.019	0.018	0.017	0.016	0.015	0.014	0.014	0.014
NMVOC	2A6	0.021	0.019	0.018	0.017	0.017	0.016	0.020	0.022	0.022	0.022
	2F Consumption of Halocarbons and SF6	**Gg CO_2 eq**									
HFC	2F1, 2F4	2.32	2.99	3.28	3.77	4.33	4.38	4.39	4.66	5.08	5.33
PFC		3.E-03	7.E-03	9.E-03	1.E-02	0.02	0.03	0.04	0.05	0.06	0.05
SF6	2F8	9.2E-02	1.7E-01	2.6E-01	2.6E-01	2.8E-01	2.7E-01	5.9E-02	1.2E-01	3.6E-01	1.4E-01
Sum	**2F**	**2.41**	**3.17**	**3.54**	**4.04**	**4.63**	**4.68**	**4.49**	**4.83**	**5.50**	**5.53**

Gas	Category	2010
	2A Mineral Products	**Gg**
CO	2A5	0.013
NMVOC	2A6	0.021
	2F Halocarbons & SF6	**Gg CO_2 eq**
HFC	2F1, 2F4	6.64
PFC		0.07
SF6	2F8	2.5E-02
Sum	**2F**	**6.74**

The most obvious features of the emissions from industrial processes may be characterised as follows: The most relevant emissions in sector 2 are those of HFCs. The use of HFC started to be relevant as of 1992 when substances were introduced as substitutes for CFCs. Since then, HFC use experienced a steep growth from 0.009 Gg CO_2 eq in 1992 up to 6.64 Gg CO_2 eq in 2010. Nevertheless, the HFC emissions contribute in 2010 only 3.4% to the emission total, all synthetic gases together 3.5%.

4.2 *Source Category 2A – Mineral Products*

4.2.1 Source Category Description

Details on source category 2A “Mineral Products” are provided in the table below:

Table 4-2 Specification of source category 2A “Mineral Products”

2A	Source	Specification	Data Source
2A1	Cement Production	Not occurring in Liechtenstein.	-
2A2	Lime Production	Not occurring in Liechtenstein.	-
2A3	Limestone and Dolomite Use	Not occurring in Liechtenstein.	-
2A4	Soda Ash Production and Use	Not occurring in Liechtenstein.	-
2A5	Asphalt Roofing	Emissions of CO and NMVOC from asphalt roofing	AD: OS 2011c EF: FOEN 2011
2A6	Road Paving with Asphalt	Emissions of NMVOC from road paving	AD: OS 2011c EF: FOEN 2011
2A7	Other	Not occurring in Liechtenstein.	-

4.2.2 Methodological Issues

4.2.2.1 Asphalt Roofing (2A5) and Road Paving with Asphalt (2A6)

Methodology

For the determination of CO and NMVOC emissions from asphalt roofing and NMVOC emissions from road paving with asphalt, data availability in Liechtenstein is very limited. In order to establish rough estimates of emissions for Liechtenstein, the specific emissions per inhabitant in Switzerland (from FOEN 2011) are used as a proxy:

Emissions of CO and NMVOC from 2A5 and 2A6 in Liechtenstein are the product of *the specific emissions per inhabitant in Switzerland* times *the number of inhabitants in Liechtenstein*[8].

This allows for a first preliminary estimate of emissions. The rationale behind this simple approach is that the general characteristics of Liechtenstein and Switzerland determining emissions are roughly similar.

Emission Factors

Emission factors for CO and NMVOC, the specific emissions per inhabitant, are calculated by dividing the emissions from Asphalt Roofing (2A5) and Road Paving with Asphalt (2A6) from the Swiss national inventory (FOEN 2011) by the number of inhabitants in Switzerland (see Table 4-3).

[8] This approach is used for all years but the latest (2010). Here, for Liechtenstein the specific emission factor of Switzerland of the previous year (2009) are used, because the Swiss National Inventory (NIR) is published only after the drafting of Liechtenstein's NIR. For the next submission, the emission factors used for Liechtenstein will be updated according to the latest Swiss NIR.

Activity Data

The activity data is the number of inhabitants in Liechtenstein as provided in the Table below (OS 2011c). For the year 2010 preliminary data for the number of inhabitants is taken from OS 2011d.

Table 4-3 Inhabitants in Liechtenstein 1990 - 2010 (OS 2011c and OS 2011d) and inhabitants in Switzerland (SFOE 2011).

Inhabitants	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Liechtenstein	**29'032**	**29'386**	**29'868**	**30'310**	**30'629**	**30'923**	**31'143**	**31'320**	**32'015**	**32'426**
Switzerland	6'796'000	6'880'000	6'943'000	6'989'000	7'037'000	7'081'000	7'105'000	7'113'000	7'132'000	7'167'000
Liechtenstein/Switzerland	0.43%	0.43%	0.43%	0.43%	0.44%	0.44%	0.44%	0.44%	0.45%	0.45%

Inhabitants	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Liechtenstein	**32'863**	**33'525**	**33'863**	**34'294**	**34'600**	**34'905**	**35'168**	**35'356**	**35'589**	**35'894**
Switzerland	7'209'000	7'285'000	7'343'000	7'405'000	7'454'000	7'501'000	7'558'000	7'619'000	7'711'000	7'801'000
Liechtenstein/Switzerland	0.46%	0.46%	0.46%	0.46%	0.46%	0.47%	0.47%	0.46%	0.46%	0.46%

Inhabitants	**2010**
Liechtenstein	**35'157**
Switzerland	7'870'000
Liechtenstein/Switzerland	0.45%

The number of inhabitants in Liechtenstein has been adjusted for the years 2007, 2008 and 2009 due to adjusted data in (OS 2011c). Preliminary data on the Swiss inhabitants for the year 2009 has been adjusted according to the definite data published in SFOE 2011.

4.2.3 Uncertainties and Time-Series Consistency

No uncertainty assessment has been executed for CO and NMVOC emissions according to the IPCC guidelines.

The time series is consistent.

4.2.4 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010). In addition, the data for Swiss inhabitants have been checked with the new data source.

4.2.5 Source-Specific Recalculations

The number of inhabitants in Liechtenstein has been adjusted for the years 2007, 2008 and 2009 due to new data in (OS 2011c). Preliminary data on the Swiss inhabitants for the year 2009 has been adjusted according to the definite data published in SFOE 2011.

4.2.6 Source-Specific Planned Improvements

Following a technical error, in 2010 the underlying population numbers for Liechtenstein as used for sector 4.2 are not correct. This error will be addressed by a recalculation in the next submission.

4.3 Source Category 2B – Chemical Industry

GHG emissions from source category 2B are not occurring in Liechtenstein.

4.4 Source Category 2C – Metal Production

GHG emissions from source category 2C are not occurring in Liechtenstein.

4.5 Source Category 2D – Other Production

GHG emissions from source category 2D are not occurring in Liechtenstein.

4.6 Source Category 2E – Production of Halocarbons and SF_6

GHG emissions from source category 2E are not occurring in Liechtenstein.

4.7 Source Category 2F – Consumption of Halocarbons and SF_6

4.7.1 Source Category Description

Key category 2F
HFC from source category 2F "Consumption of halocarbons and SF6" is a key category regarding level and trend (see Table 1-3).

Source category 2F comprises HFC, PFC and SF_6 emissions from consumption of the applications listed below. Other applications are not occurring in Liechtenstein.

Table 4-4 Specification of source category 2F "Consumption of Halocarbons and SF_6" (AD: activity data; EF: emission factors).

2F	Source	Specification	Data Source
2F1	Refrigeration and Air Conditioning Equipment	Emissions from Refrigeration and Air Conditioning Equipment	AD: Number of households, employees, passenger cars EF: Industry data for Switzerland (FOEN 2011, Carbotech 2011)
2F2	Foam Blowing	Emissions from Refrigeration and Air Conditioning Equipment	AD: Number of households, employees, passenger cars EF: Industry data for Switzerland (FOEN 2011, Carbotech 2011)
2F8	Electrical Equipment	Emissions from use in electrical equipment	AD: Industry data EF: Industry data

4.7.2 Methodological Issues

2F1 Refrigeration and Air Conditioning Equipment

Methodology

Liechtenstein does not have the relevant import statistics or industry data which would allow developing specific data models to estimate the emissions under source category 2F1. Therefore the emissions for Liechtenstein are estimated using a country specific methodology by applying the rule of proportion on basis of the emissions reported by Switzerland and specific indicators such as number of households, number of employees, number of cars, etc. As it can be assumed that the consumption patterns for industry, service sector and household sector of Liechtenstein are very similar to Switzerland, this approach will result in reliable figures for Liechtenstein. While the emission factors are assumed to be identical for both countries, the specific indicators for the rule of proportion calculation are chosen under the criteria that they shall be suitable to derive the activity data for Liechtenstein on basis of data for Switzerland. Since the National Inventory report 2010 for Liechtenstein (OEP 2010b), all gases including the PFCs as reported by Switzerland are included and emission data for 1990 is also estimated by applying the rule of proportion. In earlier inventories the emissions reported for 1990 were based on a country specific estimate, while emissions for later years were estimated by applying the rule of proportion.

More details of the underlying data models can be seen from the National Inventory Report for Switzerland (FOEN 2011) and Carbotech 2011.

In the present submission of the National Inventory Report by Liechtenstein, EFs used to estimate emissions from the consumption of halocarbons and SF_6 are still based on the GHG inventory submitted by Switzerland for 2009 (FOEN 2011), as the 2012 submission by Switzerland was not available at that time. Revised estimates are submitted once the Swiss activity data for the same year of Liechtenstein submission become available.

Manufacturing of refrigeration and air conditioning equipment is not occurring in Liechtenstein. Disposal of retired equipment falling under the categories of Domestic Refrigeration, Mobile Air Conditioning and Transport Refrigeration is by large through a single recycling company in Liechtenstein (Elkuch Recycling AG). The recycling company collects and exports the equipment to Switzerland or Austria without recovery of the synthetic gases in the refrigeration or Air Conditioning units. Nevertheless, Liechtenstein’s emissions are estimated on basis of the rule of proportion applied onto the sum of emissions for Switzerland including manufacturing, product life emissions and disposal losses. For more precision, the rule of proportion should be restricted to product life emissions and the Swiss manufacturing emissions should be excluded from the calculation. Since the manufacturing emissions in Switzerland are of low relative importance, this bias is neglected. The inclusion of emissions from disposal are a conservative estimate for Liechtenstein. As the statistical basis for a more detailed analysis is not available, the effect is also neglected and the conservative estimation is accepted. For Switzerland, the emissions from manufacturing and disposal account for 9% of the total emissions under source category 2F1 (emission data of the inventory year 2009).

For the period from 2004 to 2006 a stagnating trend can be noted for HFCs emissions with only a marginal interannual increase in an otherwise strongly increasing long term trend between 1990 and 2009. This is on account of a temporary decreasing trend in the underlying Swiss GHG inventory in the period 2004 – 2006 for HFC 134a emissions from stock related to commercial refrigeration.

The inventory under this source category includes the following types of equipment: domestic refrigeration, commercial and industrial refrigeration, transport refrigeration, stationary air conditioning and mobile air conditioning. The indicators used for the rule of proportion calculations are summarised in the following table.

Table 4-5 Indicators used in calculating Liechtenstein's emissions for source category 2F1 on basis of Switzerland's emissions by applying rule of proportion.

Application	**Refrigerant**	**Base value**	**Indicator for calculation by rule of proportion**
Domestic Refrigeration	HFC-134a	Total emissions reported for Switzerland	Number of households
Commercial Refrigeration	HFC-125 HFC-134a HFC-143a C3F8	Total emissions reported for Switzerland	Number of persons employed in industrial and service sector
Transport Refrigeration	HFC-125 HFC-134a HFC-143a	Total emissions reported for Switzerland	Number of inhabitants
Industrial Refrigeration	Included in commercial refrigeration		
Stationary Air Conditioning	HFC-32 HFC-125 HFC-134a HFC-143a	Total emissions reported for Switzerland	Number of persons employed in industrial and service sector
Mobile Air Conditioning	HFC-134a	Total emissions reported for Switzerland (cars, trucks, railway)	Number of registered cars

Emission Factors

Due to the approach chosen, the emission factors as reported in the Swiss National Inventory Report (FOEN 2011) are applicable.

The data reported in Table 4-8 is taken from FOEN 2011 and shows details to the emission factors. No manufacturing of refrigeration and air conditioning equipment is occurring in Liechtenstein.

Table 4-6 Typical values on life time, charge and emission factors used in model calculations for Refrigeration and Air Conditioning Equipment. Where values in brackets are provided, the first value shows the assumption for 1995 while the second value (in brackets) shows the assumption for 2010 respectively 2020. Data between 1995 and 2010 respectively 2020 is linearly interpolated. Source: FOEN 2011, Carbotech 2011.

Equipment type	Product life time [a]	Initial charge of new product [kg]	Manufacturing emission factor [% of initial charge]	Product life emission factor [% per annum]	Charge at end of life [% of initial charge of new product] *)	Disposal loss emission factor [% of remaining charge
Domestic Refrigeration	12	0.1	NO	0.5	94	19 **)
Commercial and Industrial Refrigeration	10	NR	0.5	12 (2020: 5)	100	10
Transport Refrigeration / Trucks	10	1.8 … 7.8	1	15	100	20
Transport Refrigeration / Railway	12	NR	NO	10	100	20
Stationary Air Conditioning (direct / indirect cooling system)	15	NR	3 / 1	direct: 10 (2010: 3) indirect: 6 (2010: 4)	100	28 / 19
Heat Pumps	15	4.7 …7.5 till 1999 Going down to 2.8 …4.5 in 2010	3	2	100	10
Mobile Air Conditioning / Cars	12	0.7 (0.83) ***)	NO	8.5	64	100 until year 2000 30 since 2001
Mobile Air Conditioning / Trucks	10	1.1	NO	10 until year 2000 Going down to 8.5 in 2010	35	100 until year 2000 30 since 2001
Mobile Air Conditioning / Buses	10	7.5	NO	10 until year 2000 Going down to 8.5 in 2010	35	100 until year 2000 30 since 2001
Mobile Air Conditioning / Railway	12	20	NO	4	100	10

*) takes into account refill of losses during product life where applicable.

**) takes into account R134a content in foams, based on information from the national recycling organisation SENS.

***) Assumed constant since 2002. 0.83 kg in 1990. Linear interpolation between 1990 and 2002.

NA = not available
NR = not relevant as only aggregate data is used
NO = Not occurring (only import of charged units)

Activity Data

Activity data for Liechtenstein is calculated based on activity data for Switzerland with the methodology as described above. The following figures have been used for the indicators:

Table 4-7 Figures used as indicators for calculation of activity data by applying rule of proportion.

	1990		2010	
Number of households				
Liechtenstein	10'556	Source: National census 1990 (OEA 2000)	16'305	Source: National census 2000 with trend extrapolation (OEA 2000)
Switzerland	2'859'766	Source: National census 1990 (SFSO 2011a)	3'522'048	Source: National census 2000 with trend extrapolation (SFSO 2011a)
Conversion Factor CH→LIE	0.0036912		0.00462941	
Number of employees in industrial and service sector				
Liechtenstein	19'554	Source: Statistical Yearbook Liechtenstein (OS 2011b)	35'079	Source: Statistical Yearbook Liechtenstein (OS 2011b)
Switzerland	3'664'214	Source: National census of enterprises 1985 and 1991, interpolated (SFSO 2011b)	3'732'602	Source: National census of enterprises 2001 and 2005, extrapolated (SFSO 2011b)
Conversion Factor CH→LIE	0.0053365		0.0093980	
Number of registered passenger cars				
Liechtenstein	16'891	Source: Statistical Yearbook Liechtenstein (OS 2011c)	26'890	Source: Statistical Yearbook Liechtenstein (OS 2011c)
Switzerland	2'985'399	Source: National motorcar statistics for Switzerland (SFSO 2011c)	4'075'825	Source: National motorcar statistics for Switzerland (SFSO 2011c)
Conversion Factor CH→LIE	0.0056579		0.0065974	

2F2 Foam Blowing

Methodology

Liechtenstein does not have the relevant import statistics or industry data which would allow developing specific data models to estimate the emissions under source category 2F2. Therefore the emissions for Liechtenstein are estimated using a country specific methodology by applying the rule of proportion on basis of the emissions reported by Switzerland based on number of inhabitants. As it can be assumed that the consumption patterns of Liechtenstein are very similar to Switzerland, this approach will result in reliable figures for Liechtenstein. While the emission factors are assumed to be identical for both countries, the specific indicator for the rule of proportion calculation is chosen under the criteria that it shall be suitable to derive the activity data for Liechtenstein on basis of data for Switzerland. As manufacturing of foams is not occurring in Liechtenstein, only emissions during life of product and disposal are considered. Emissions under source category 2F2are related to hard foams only. For soft foams, manufacturing using HFC is not occurring in Switzerland or Liechtenstein. As for soft foams emissions are occurring only during production emissions from soft foams are NO.

More details of the underlying data models can be seen from the National Inventory Report for Switzerland (FOEN 2011) and Carbotech 2011.

Emission Factors

Due to the approach chosen, the emission factors as reported in the Swiss National Inventory Report (FOEN 2011) are applicable.

The data reported in Table 4-8 is taken from FOEN 2011 and shows details to the emission factors. No manufacturing of foams is occurring in Liechtenstein.

Table 4-8 Typical values on life time, charge and emission factors used in model calculations for foam blowing. Source: FOEN 2011, Carbotech 2011.

Application		**Product life time** years	**Charge of new product** % of product weight	**Manufacturing emission factor** % of initial charge	**Product life emission factor** % per annum	**Charge at end of life** % charge of new product
PU foam		50	4.5	NR	NR	NR
XPS foam	HFC 134a HFC 152a	50	6.5	NO	10 / 0.7** 100 / 0**	64% 0%
PU spray		50	13.6 / 0 *	0.8	95 / 2.5 **	0
Sandwich Elements		50	3	10/100 ***	0.5 / 0 ***	78 / 0 ***

* Data for 1990 / 2009
** Data for 1st year / following years
*** First value for R134a, R227ea, R365mfc and second value for R152a
NR Not relevant, because no substances according to this protocol has been used, all emissions occur outside Switzerland during production
NO Not occurring, because XPS not produced in Switzerland

Activity Data

Activity data for Liechtenstein is calculated based on activity data for Switzerland with the methodology as described above. The following figures have been used for the indicators:

Table 4-9 Figures used as indicator for calculation of activity data by applying rule of proportion.

	2010	
Number of Inhabitants		
Liechtenstein	35’157	Source: Statistical Yearbook Liechtenstein (OS 2011d)
Switzerland	7'870'000	Source: (SFSO 2011d)
Conversion Factor CH→LIE	0.004467	

2F4 Aerosols / Metered Dose Inhalers

Methodology

Liechtenstein does not have the relevant import statistics or industry data which would allow developing specific data models to estimate the emissions under source category 2F4 Aerosols / Metered Dose Inhalers. Therefore the emissions for Liechtenstein are estimated using a country specific methodology by applying the rule of proportion on basis of the emissions reported by Switzerland and using the number of inhabitants as indicator. As it can be assumed that the consumption patterns of Liechtenstein are very similar to Switzerland, this approach will result in reliable figures for Liechtenstein. While the emission factors are assumed to be identical for both countries, the specific indicator for the rule of proportion calculation is chosen under the criteria that it shall be suitable to derive the activity data for Liechtenstein on basis of data for Switzerland. To restrict the complexity of the estimation model for Liechtenstein, gases with very low emissions in Switzerland are neglected. The absolute relevance of the emissions reported under 2F4 is very low (less than 0.1 Gg CO_2eq) and therefore inaccuracies in the estimation model are considered negligible.

More details of the underlying data models can be seen from the National Inventory Report for Switzerland (FOEN 2011) and Carbotech 2011.

Emission Factors

Due to the approach chosen, the emission factors as reported in the Swiss National Inventory Report (FOEN 2011) are applicable.

Activity Data

Activity data for Liechtenstein is calculated based on activity data for Switzerland with the methodology as described above. The figures as seen in Table 4-9 have been used as indicator.

2F8 Electrical Equipment

Methodology

The only SF_6 emissions in Liechtenstein stem from the transformers operated by the utility Liechtensteinische Kraftwerke (LKW). The LKW reports on activity data and emissions with a T3 method. A complete mass balance analysis is conducted by LKW on installation level, which was reconfirmed by LKW in 2011. No production of equipment with SF_6 is occurring.

Emission Factors

Emission factors for this source category are based on industry information.

Activity Data

Activity data is based on industry information. Before 1995/1996 a different technology was applied which did not use SF_6.

4.7.3 Uncertainties and Time-Series Consistency

For source category 2F Consumption of halocarbons and SF6 no specific uncertainties have been determined. For the Swiss GHG inventory (FOEN 2011), the uncertainties of the emissions of HFC under source category 2F were at 15.2% (Monte Carlo simulation based on 2009 data).

For Liechtenstein's uncertainty analysis, a value of 16% was adopted for HFC (key category) although it might be somewhat higher due to the conversion of Swiss into Liechtenstein data. For the emissions of PFC and SF_6 in 2F (non-key category), a "medium" uncertainty of 20% according to Table 1-6 is assumed.

The methods for calculating the emissions of the full time series 1990–2010 are consistent.

4.7.4 Source-Specific QA/QC and Verification

In order to confirm the plausibility of the emission data for Liechtenstein the NIR authors have performed various cross-checks between the CRF data for source category 2F Consumption of halocarbons and SF6 as reported for Switzerland and Liechtenstein. The emissions for Liechtenstein under this source category are estimated to a large extent by applying the rule of proportion as used for respective data in Switzerland. Consistency of the data was confirmed by these checks.

Under 2F3, emissions from Fire Extinguishers are reported as not occurring since no emissions are occurring in this sector within Switzerland. The application of HFC, PFC and SF_6 in fire extinguishers is prohibited by law in Switzerland. For the 2009 GHG inventory of Liechtenstein (OEP 2011a) it has been checked with industry representatives if this assumption is correct also for Liechtenstein. They confirmed that there is neither production nor disposal or known stocking of fire extinguishers using HFC, PFC or SF_6. Therefore it can be assumed that the notation key NO is correct for Liechtenstein.

For the inventory 2009 (OEP 2011a) the sum of SF_6 emissions reported by Liechtenstein for 1996-2009 for source category 2F8 Electrical Equipment as potential and actual emissions have been checked with the Liechtensteinische Kraftwerke (LKW 2010) and were confirmed to be reasonable in view of the installation based data from the electrical equipment operated by the Liechtensteinische Kraftwerke.

Referring to the last submission, in CRF Table2(II)s2 for HFC and PFC actual emissions and potential/actual emission ratio are shown while the potential emissions are indicated as not occurring (NO) which is not correct. Checks have been performed to identify the problem with the result that this seems to be a problem of the CRF reporter which can not be solved by Liechtenstein. The potential emission data is available in the table CRF Table 2(I)s2.

In addition to these source-specific activities, the source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010).

4.7.5 Source-Specific Recalculations

Due to a technical error, actual emissions from HFC 134a in Sector 2F1 “Refrigeration and Air Conditioning Equipment” have been recalcalculated for the years 2008 and 2009. In submission 2010 and 2011 for these two years activity data from manufacturing were mistakenly reported, although no manufacturing exists in Liechtenstein. This error is now corrected for the submission 2012.

4.7.6 Source-Specific Planned Improvements

Gradual improvement of the data quality in co-operation with industry is ongoing for the Swiss GHG inventory. Methodologies and emission models will be updated during the yearly process of F-gas inquiry. The focus will be on improvements of HFC-emission calculations from refrigeration and air-conditioning equipment. As the GHG emissions for Liechtenstein under source category 2F are methodologically based on the Swiss GHG inventory data this will also benefit the GHG inventory for Liechtenstein.

At the time of preparing the CRF tables for the present submission a major revision was planned for the GHG inventory of Switzerland in order to properly separate the emissions of Switzerland and Liechtenstein with the aim to avoid double counting (note: Switzerland and

Liechtenstein have a common import statistic. So far the GHG inventory of Switzerland reports under the source category 2F the sum of emissions occurring in Switzerland and Liechtenstein wherever emission models are based on data taken from import statistics). Therefore it was decided that no recalculation for the period 1990-2009 is made.

In the meantime the planned major revision had to be delayed and only will be effective for the submission of the GHG inventory of Switzerland in April 2013. Once this is implemented, OEP will analyse the situation and will then decide if the methodology for the inventory of Liechtenstein for source category 2F will be revised. If a revision is conducted, this will also lead to recalculation of the data for the entire time period starting from 1990.

Due to a technical error, the underlying population number for the year 2010 used is not correct. This error will be addressed by a recalculation in the next submission.

4.8 Source Category 2G – Other

GHG emissions from source category 2G are not occurring in Liechtenstein.

5 Solvent and Other Product Use

5.1 Overview

Considerable changes have been made in Chapter 5 for the current submission. The emissions of indirect CO_2 due to atmospheric decomposition of NMVOC are now reported in sector 7 Other (Chapter 9).

This chapter provides information on the estimation of greenhouse gas emissions from solvent and other product use. Reported emissions comprise NMVOC emissions from the use of solvents. Also reported are CO_2 emissions resulting from post-combustion of NMVOCs. Furthermore, evaporative emissions of N_2O arising from other types of product use and from medical use are included.

Source category 3 "Solvent and Other Product Use" is **not a key category.**

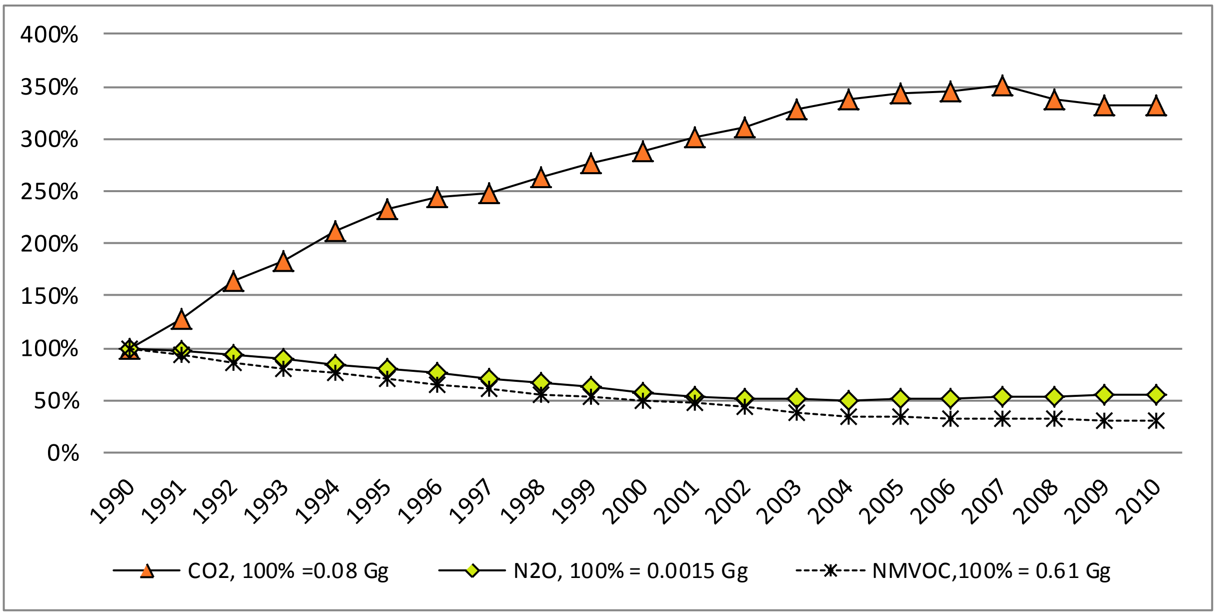


Figure 5-1 Overview of emissions in category 3 Solvent and Other Product Use in Liechtenstein 1990–2010.

Table 5-1 Emissions of source category 3 Solvent and Other Product Use.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Gg									
CO_2	0.08	0.11	0.14	0.15	0.18	0.19	0.20	0.21	0.22	0.23
N_2O	0.0015	0.0015	0.0014	0.0013	0.0013	0.0012	0.0011	0.0011	0.0010	0.0009
NMVOC	0.61	0.56	0.53	0.49	0.46	0.43	0.40	0.37	0.34	0.32

Gas	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	Gg									
CO_2	0.24	0.25	0.26	0.27	0.28	0.29	0.29	0.29	0.28	0.28
N_2O	0.0009	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
NMVOC	0.30	0.28	0.26	0.24	0.21	0.20	0.20	0.19	0.19	0.19

Gas	2010
	Gg
CO_2	0.28
N_2O	0.0008
NMVOC	0.19

The emissions of NMVOC, CO_2 and N_2O are all calculated by a country specific method from the corresponding Swiss emissions by using the specific emission per inhabitant as conversion factors. Two reduction efforts are responsible for the decrease of the emissions: The limitation of the application of NMVOC brought by the legal restrictions (Government 1986 and 2003) and the introduction of the VOC-levy in 2000 in Liechtenstein and Switzerland (based on the Customs Union Treaty the Swiss VOC-levy is also applicable in Liechtenstein).

5.2 Source Category 3A – Paint Application

5.2.1 Source Category Description

Source category 3A Paint Application comprises NMVOC emissions from paints, lacquers, thinners and related materials used in coatings in industrial, commercial and household applications. Also, it includes direct CO_2 emissions resulting from post-combustion of NMVOC to reduce NMVOC in exhaust gases.

Table 5-2 Specification of source category 3A “Paint Application”.

	Source	Specification	Data Source
3A	Paint Application	Paint application in households, industry and construction	AD: OS 2011c EF: FOEN 2011

5.2.2 Methodological Issues

5.2.2.1 Methodology

Data availability in Liechtenstein is very limited. In order to establish rough estimates of emissions for Liechtenstein, the specific emissions per inhabitant in Switzerland are used as a proxy:

Emissions of NMVOC and CO_2 from the source category 3A in Liechtenstein are the product of *the specific emissions per inhabitant in Switzerland* times *the number of inhabitants in Liechtenstein*.[9]

This allows for a first preliminary estimate of emissions. The rationale behind this simple approach is that the general characteristics of Liechtenstein and Switzerland determining emissions are roughly similar.

5.2.2.2 Emission Factors

Emission factors for NMVOC and CO_2, the specific emissions per inhabitant, are calculated by dividing the emissions from source category 3A from the Swiss national inventory (FOEN 2011) by the number of inhabitants in Switzerland (see Table 4-3 in section 4.2.2).

Table 5-3 Emission factors - specific emissions per inhabitant 1990 to 2010 (Source: Swiss emissions from FOEN 2011; inhabitants see Section 4.2.2).

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3A. Paint Application											
CO_2	g/inhabitant	120	252	383	394	437	435	433	435	444	455
NMVOC	g/inhabitant	6'175	5'953	5'719	5'468	5'185	4'874	4'531	4'167	3'766	3'584

Source	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3A. Paint Application											
CO_2	g/inhabitant	456	453	425	424	397	395	556	585	618	611
NMVOC	g/inhabitant	3'404	3'213	2'726	2'189	1'607	1'578	1'546	1'512	1'453	1'396

Source	Unit	2010
3A. Paint Application		
CO_2	g/inhabitant	611
NMVOC	g/inhabitant	1'396

5.2.2.3 Activity Data

The development of the number of inhabitants in Liechtenstein is provided in Section 4.2.2.

5.2.3 Uncertainties and Time-Series Consistency

The uncertainty of CO_2 emissions from the entire source category 3 Solvent and Other Product Use is estimated to be 80% (expert estimate based on uncertainty of Swiss data and uncertainty of simple approach).

For NMVOC emissions no uncertainty assessment is done according to the IPCC guideline.

The time series is consistent.

5.2.4 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010).

Data for Liechtenstein's inhabitants have been checked with the population statistics published on the internet.

[9] This approach is used for all years but the latest (2010). Here, for Liechtenstein the specific emission factor of Switzerland of the previous year (2009) are used, because the Swiss National Inventory is published only after the drafting of Liechtenstein's NIR. For the next submission, the emission factors used for Liechtenstein will be updated according to the latest Swiss NIR.

5.2.5 Source-Specific Recalculations

The number of inhabitants in Liechtenstein has been adjusted for the years 2007, 2008 and 2009 due to adjusted data in (OS 2011c). Preliminary data on the Swiss inhabitants for the year 2009 has been adjusted according to the definite data published in SFOE 2011.

5.2.6 Source-Specific Planned Improvements

Following a technical error, in 2010 the underlying population numbers for Liechtenstein as used for sector 4.2 are not correct. This error will be addressed by a recalculation in the next submission.

5.3 Source Category 3B – Degreasing and Dry Cleaning

5.3.1 Source Category Description

Source category 3B comprises NMVOC emissions from degreasing, dry cleaning and cleaning in electronic industry. It further includes direct CO_2 emissions resulting from post-combustion of NMVOC to reduce NMVOC in exhaust gases.

Table 5-4 Specification of source category 3B "Degreasing and Dry Cleaning".

	Source	Specification	Data Source
3B	Degreasing and Dry Cleaning	Degreasing; dry cleaning; cleaning of electronic components; cleaning of parts in metal processing; other industrial cleaning	AD: OS 2011c EF: FOEN 2011

5.3.2 Methodological Issues

5.3.2.1 Methodology

Data availability in Liechtenstein is very limited. In order to establish rough estimates of emissions for Liechtenstein, the specific emissions per inhabitant in Switzerland are used as a proxy:

Emissions of NMVOC and CO_2 from the source category 3B in Liechtenstein are the product of *the specific emissions per inhabitant in Switzerland* and *the number of inhabitants in Liechtenstein*.[10]

This basis allows a first preliminary estimate of emissions. The rationale behind this simple approach is that the general characteristics of Liechtenstein and Switzerland determining emissions are mainly similar.

[10] This approach is used for all years but the latest (2010). Here, for Liechtenstein the specific emission factor of Switzerland of the previous year (2009) are used, because the Swiss National Inventory is published only after the drafting of Liechtenstein's NIR. For the next submission, the emission factors used for Liechtenstein will be updated according to the latest Swiss NIR.

5.3.2.2 Emission Factors

Emission factors for NMVOC and CO_2, the specific emissions per inhabitant, are calculated by dividing the emissions from source category 3B from the Swiss national inventory (FOEN 2011) by the number of inhabitants in Switzerland (see Table 4-3 in section 4.2.2).

Table 5-5 Emission factors - specific emissions per inhabitant 1990 to 2010 (Source: Swiss emissions from FOEN 2011; inhabitants see Section 4.2.2).

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3B. Degreasing and Dry Cleaning											
CO_2	g/inhabitant	0	0	6	12	12	12	12	12	12	12
NMVOC	g/inhabitant	1'785	1'619	1'466	1'322	1'184	1'052	928	810	695	653

Source	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3B. Degreasing and Dry Cleaning											
CO_2	g/inhabitant	12	12	11	11	11	11	11	11	11	11
NMVOC	g/inhabitant	610	564	521	477	434	400	366	333	325	317

Source	Unit	2010
3B. Degreasing and Dry Cleaning		
CO_2	g/inhabitant	11
NMVOC	g/inhabitant	317

5.3.2.3 Activity Data

The development of the number of inhabitants in Liechtenstein is provided in Section 4.2.2.

5.3.3 Uncertainties and Time-Series Consistency

The uncertainty of CO_2 emissions from the entire source category 3 Solvent and Other Product Use is estimated to be 80% (expert estimate based on uncertainty of Swiss data and uncertainty of simple approach).

For NMVOC emissions no uncertainty assessment is done according to the IPCC guideline.

The time series is consistent.

5.3.4 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010).

Data for Liechtenstein's inhabitants have been checked with the population statistics published on the internet.

5.3.5 Source-Specific Recalculations

The number of inhabitants in Liechtenstein has been adjusted for the years 2007, 2008 and 2009 due to adjusted data in (OS 2011c). Preliminary data on the Swiss inhabitants for the year 2009 has been adjusted according to the definite data published in SFOE 2011.

Updated emission factors for metal degreasing and dry cleaning were available for Switzerland. This has led to updated specific emissions per inhabitant in Switzerland for the years 1990 to 2009 (FOEN 2011). As the specific emissions per inhabitant in Switzerland are used as a proxy for source category 3B, recalculations have been made for the years 1990 to 2009.

5.3.6 Source-Specific Planned Improvements

Following a technical error, in 2010 the underlying population numbers for Liechtenstein as used for sector 4.2 are not correct. This error will be addressed by a recalculation in the next submission.

5.4 Source Category 3C – Chemical Products, Manufacture and Processing

5.4.1 Source Category Description

Source category 3C Chemical Products, Manufacture and Processing comprises NMVOC emissions from manufacturing and processing of chemical products. Also, it includes direct CO_2 emissions resulting from post-combustion of NMVOC to reduce NMVOC in exhaust gases.

Table 5-6 Specification of source category 3C “Chemical Products, Manufacture and Processing”.

	Source	**Specification**	**Data Source**
3C	Chemical Products, Manufacture and Processing	Handling and storage of solvents; fine chemical production; production of pharmaceuticals; manufacturing of paint, inks, glues, adhesive tape, rubber; processing of PVC, polystyrene foam, polyurethane and polyester	AD: OS 2011c EF: FOEN 2011

5.4.2 Methodological Issues

5.4.2.1 Methodology

Data availability in Liechtenstein is very limited. In order to establish rough estimates of emissions for Liechtenstein, the specific emissions per inhabitant in Switzerland are used as a proxy:

Emissions of NMVOC and CO_2 from the source category 3C in Liechtenstein are the product of *the specific emissions per inhabitant in Switzerland* and *the number of inhabitants in Liechtenstein*.[11]

This basis allows a first preliminary estimate of emissions. The rationale behind this simple approach is that the general characteristics of Liechtenstein and Switzerland determining emissions are mainly similar.

5.4.2.2 Emission Factors

Emission factors for NMVOC and CO_2, as well as the specific emissions per inhabitant, are calculated by dividing the emissions from source category 3C from the Swiss national inventory (FOEN 2011) by the number of inhabitants in Switzerland (see Table 4-3 in section 4.2.2).

[11] This approach is used for all years except the latest (2010). Here, for Liechtenstein the specific emission factor of Switzerland of the previous year (2009) is used, as the publication of the Swiss National Inventory is only after the drafting of Liechtenstein's NIR. For the next submission, the emission factors used for Liechtenstein will be updated according to the latest Swiss NIR.

Table 5-7 Emission factors - specific emissions per inhabitant 1990 to 2010 (Source: Swiss emissions from FOEN 2011; inhabitants see Section 4.2.2).

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3C. Chemical Products, Manufacture and Processing											
CO_2	g/inhabitant	1'781	1'983	2'271	2'434	2'498	2'505	2'514	2'512	2'654	2'819
NMVOC	g/inhabitant	4'162	3'362	2'633	1'934	1'715	1'474	1'261	1'115	948	885

Source	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3C. Chemical Products, Manufacture and Processing											
CO_2	g/inhabitant	2'851	2'861	3'051	3'157	3'351	3'461	3'386	3'228	3'097	3'041
NMVOC	g/inhabitant	782	708	661	624	579	563	553	549	537	527

Source	Unit	2010
3C. Chemical Products, Manufacture and Processing		
CO_2	g/inhabitant	3'041
NMVOC	g/inhabitant	527

5.4.2.3 Activity Data

The development of the number of inhabitants in Liechtenstein is provided in Section 4.2.2.

5.4.3 Uncertainties and Time-Series Consistency

The uncertainty of CO_2 emissions from the entire source category 3 Solvent and Other Product Use is estimated to be 80% (expert estimate based on uncertainty of Swiss data and uncertainty of simple approach).

For NMVOC emissions no uncertainty assessment has been executed according to the IPCC guideline.

The time series is consistent.

5.4.4 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010).

Data for Liechtenstein's inhabitants have been checked with the population statistics published on the internet.

5.4.5 Source-Specific Recalculations

The number of inhabitants in Liechtenstein has been adjusted for the years 2007, 2008 and 2009 due to new data in (OS 2011c). Preliminary data on the Swiss inhabitants for the year 2009 has been adjusted according to the definite data published in SFOE 2011.

5.4.6 Source-Specific Planned Improvements

Following a technical error, in 2010 the underlying population numbers for Liechtenstein as used for sector 4.2 are not correct. This error will be addressed by a recalculation in the next submission.

5.5 Source Category 3D – Other

5.5.1 Source Category Description

Source category 3D comprises emissions from many different solvent applications. Besides NMVOC also emissions of N_2O are relevant. Also, it includes direct CO_2 emissions resulting from post-combustion of NMVOC to reduce NMVOC in exhaust gases. Direct emissions of greenhouse gases result from the application of N_2O in households and hospitals and the emissions of CO_2 from the use of fireworks

Table 5-8 Specification of source category 3D "Other".

	Source	Specification	Data Source
3D	Other	Use of spray cans in industry and households; domestic solvent use application of glues and adhesives; use of concrete additives; removal of paint and lacquer; car underbody sealant; use of cooling lubricants and other lubricants; use of pesticides; use of pharmaceutical products in households; house cleaning industry/craft/services; hairdressers; scientific laboratories; industrial production; cosmetic institutions; use of tobacco products; wood preservation; medical practitioners; other health care institutions; no-attributable solvent emissions; use of N_2O in households and in hospitals; other use of gases; use of fireworks	AD: OS 2011c EF: FOEN 2011

5.5.2 Methodological Issues

5.5.2.1 Methodology

Data availability in Liechtenstein is very limited. In order to establish rough estimates of emissions for Liechtenstein, the specific emissions per inhabitant in Switzerland are used as a proxy:

Emissions from the source category 3D in Liechtenstein are the product of *the specific emissions per inhabitant in Switzerland* and *the number of inhabitants in Liechtenstein*.[12]

This basis allows a first preliminary estimate of emissions. The rationale behind this simple approach is that the general characteristics of Liechtenstein and Switzerland determining emissions are mainly similar.

5.5.2.2 Emission Factors

Emission factors for NMVOC, CO_2 and N_2O, the specific emissions per inhabitant, are calculated by dividing the emissions from source category 3D from the Swiss national inventory (FOEN 2011) by the number of inhabitants in Switzerland (see Table 4-3 in section 4.2.2).

[12] This approach is used for all years except the latest (2010). Here, for Liechtenstein the specific emission factor of Switzerland of the previous year (2009) are used, because the Swiss National Inventory is published only after the drafting of Liechtenstein's NIR. For the next submission, the emission factors used for Liechtenstein will be updated according to the latest Swiss NIR.

Table 5-9 Emission factors - specific emissions per inhabitant 1990 to 2010 (Source: Swiss emissions from FOEN 2011; inhabitants see Section 4.2.2).

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3D1. Other. Use of N_2O for Anaesthesia											
N_2O	g/inhabitant	43	40	38	35	32	30	27	25	22	19
3D3. Other. N_2O from Aerosol Cans											
N_2O	g/inhabitant	9	9	9	9	10	10	10	10	10	10
3D5. Other. Other. Spray cans, cosmetic institutions, etc.											
CO_2	g/inhabitant	970	1'380	1'909	2'185	2'823	3'324	3'563	3'619	3'732	3'822
NMVOC	g/inhabitant	8'809	8'250	7'770	7'328	6'892	6'462	6'047	5'642	5'239	4'826

Source	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3D1. Other. Use of N_2O for Anaesthesia											
N_2O	g/inhabitant	17	14	13	13	12	12	13	13	13	13
3D3. Other. N_2O from Aerosol Cans											
N_2O	g/inhabitant	10	10	10	10	10	10	10	10	10	10
3D5. Other. Other. Spray cans, cosmetic institutions, etc.											
CO_2	g/inhabitant	3'993	4'162	4'152	4'358	4'358	4'335	4'212	4'443	4'169	4'093
NMVOC	g/inhabitant	4'420	4'005	3'787	3'574	3'369	3'257	3'154	3'120	3'085	3'050

Source	Unit	2010
3D1. Other. Use of N_2O for Anaesthesia		
N_2O	g/inhabitant	13
3D3. Other. N_2O from Aerosol Cans		
N_2O	g/inhabitant	10
3D5. Other. Other. Spray cans, cosmetic institutions, etc.		
CO_2	g/inhabitant	4'093
NMVOC	g/inhabitant	3'050

5.5.2.3 Activity Data

The development of the number of inhabitants in Liechtenstein is provided in Section 4.2.2.

5.5.3 Uncertainties and Time-Series Consistency

The uncertainty of CO_2 emissions from the entire source category 3 Solvent and Other Product Use is estimated to be 80% (expert estimate based on uncertainty of Swiss data and uncertainty of simple approach).

For NMVOC emissions no uncertainty assessment is done according to the IPCC guideline.

The time series is consistent.

5.5.4 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010).

Data for Liechtenstein’s inhabitants have been checked with the population statistics published on the internet.

5.5.5 Source-Specific Recalculations

The number of inhabitants in Liechtenstein has been adjusted for the years 2007, 2008 and 2009 due to new data in (OS 2011c). Preliminary data on the Swiss inhabitants for the year 2009 has been adjusted according to the definite data published in SFOE 2011.

5.5.6 Source-Specific Planned Improvements

Following a technical error, in 2010 the underlying population numbers for Liechtenstein as used for sector 4.2 are not correct. This error will be addressed by a recalculation in the next submission.

6 Agriculture

6.1 Overview

This chapter provides information on the estimation of the greenhouse gas emissions from the agriculture sector (Sectoral Report for Agriculture, Table 4 in the Common Reporting Format). The following source categories are reported:

- CH_4 emissions from enteric fermentation in domestic livestock,
- CH_4 and N_2O emissions from manure management,
- N_2O emissions from agricultural soils.

Total greenhouse gas emissions from agriculture in 2010 were 22.6 Gg CO_2 equivalents in total, which is a contribution of 9.7% to the total of Liechtenstein's greenhouse gas emissions (excluding LULUCF). Main agricultural sources of greenhouse gases in 2010 were enteric fermentation emitting 10.5 Gg CO_2 equivalents, followed by agricultural soils with 8.8 Gg CO_2 equivalents. In general, emissions decreased until 2000 followed by an increase until 2007. 2008-2010 emissions show a slight decreasing trend. The overall emissions from agriculture in CO_2 equivalents in 2010 are slightly lower than in 1990 (-1.8%).

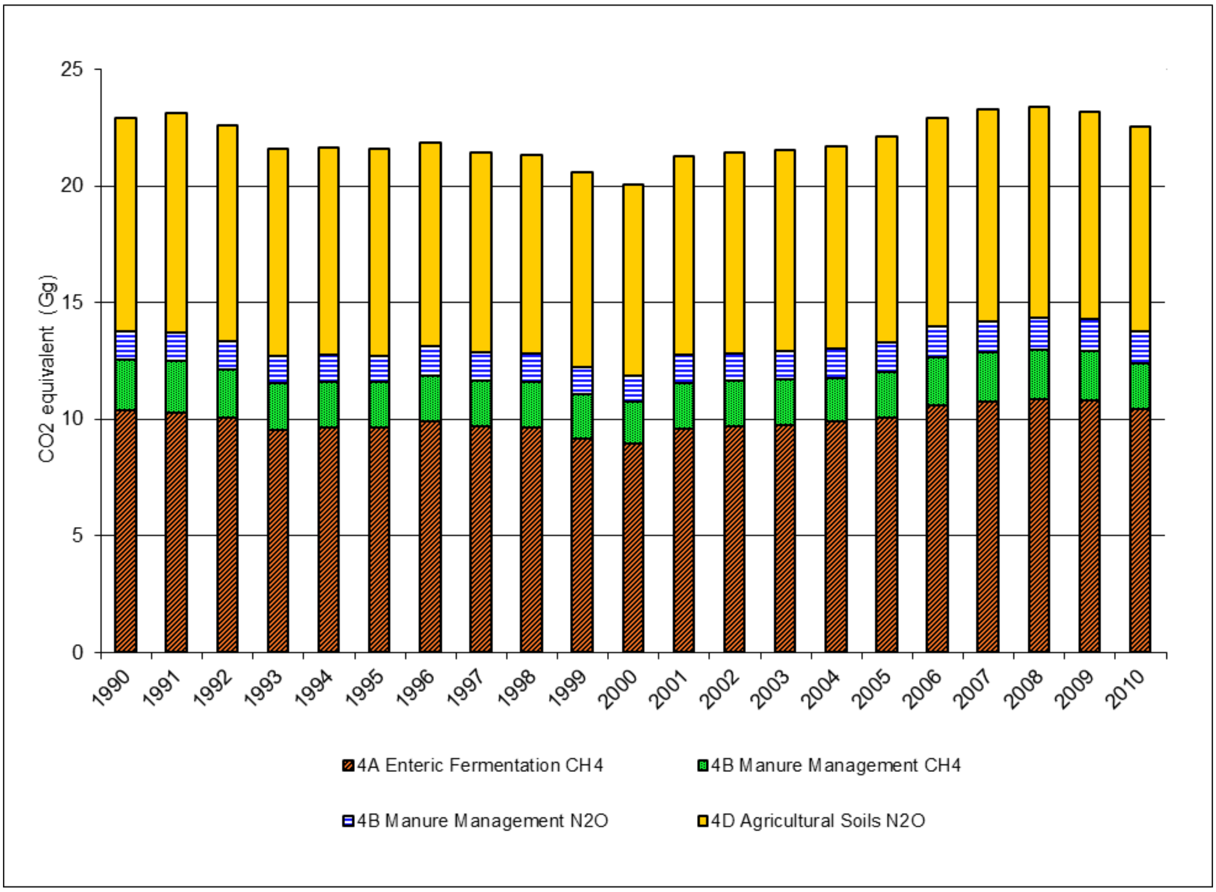


Figure 6-1 Greenhouse gas emissions in Gg CO_2 equivalents of agriculture 1990-2010.

No CO_2 emissions are reported in the agricultural sector. CO_2 emissions from energy use in agriculture are reported under Energy, Other Sectors (1A4c).

Table 6-1 Greenhouse gas emissions in Gg CO_2 equivalents of agriculture 1990-2010 (numbers may not add to totals due to rounding).

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CH_4	12.6	12.5	12.2	11.6	11.6	11.6	11.9	11.7	11.6	11.1
N_2O	10.4	10.6	10.5	10.1	10.1	10.0	10.0	9.8	9.7	9.5
Sum	**23.0**	**23.1**	**22.6**	**21.6**	**21.7**	**21.6**	**21.9**	**21.5**	**21.3**	**20.6**

Gas	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	*90-2010*
	CO_2 equivalent (Gg)											*%*
CH_4	10.8	11.6	11.7	11.7	11.8	12.1	12.7	12.9	13.0	12.9	12.4	*-1.2*
N_2O	9.3	9.7	9.8	9.8	9.9	10.1	10.3	10.4	10.4	10.3	10.1	*-2.5*
Sum	**20.1**	**21.3**	**21.5**	**21.6**	**21.7**	**22.1**	**23.0**	**23.3**	**23.4**	**23.2**	**22.6**	***-1.8***

CH_4 emissions are now 1.2% lower than in 1990 due to a decrease in cattle number (mainly mature dairy cattle). N_2O emissions decreased by 2.5% mainly due to a decreasing input of mineral fertilizers. Until 2000 CH_4 and N_2O have decreased significantly, since then they have increased again, reaching in recent years almost the level of 1990. Main driver of this development is the development of the animal populations (see also Figure 6-5).

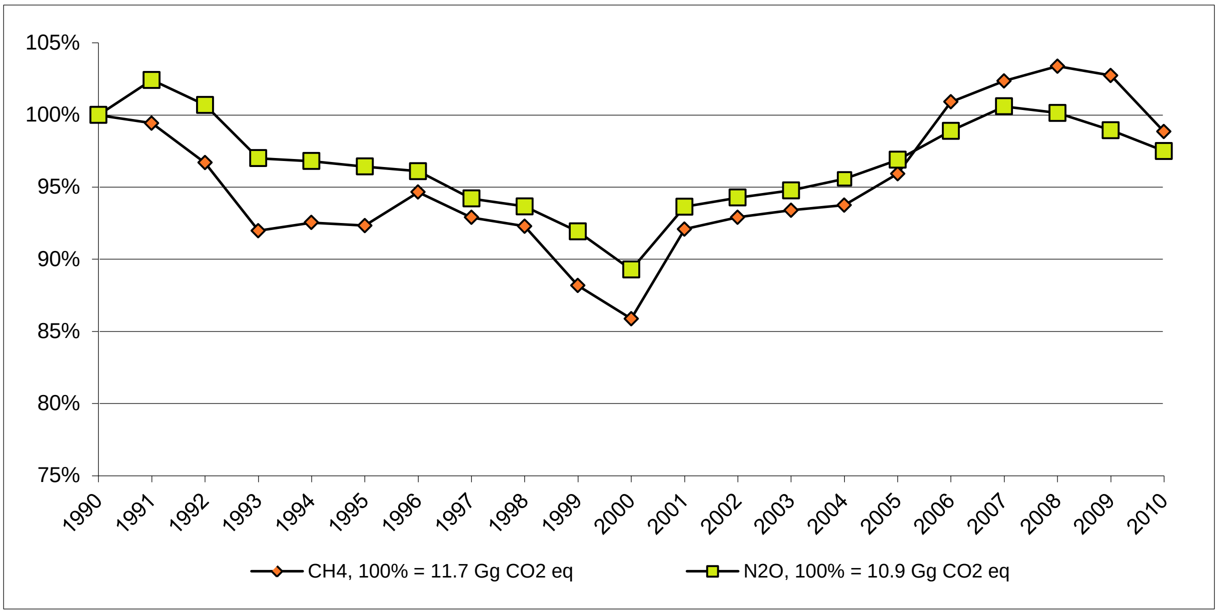


Figure 6-2 Trend of greenhouse gases of the agricultural sector 1990-2010. The base year 1990 represents 100%.

Three key sources of the inventory are outside of the agricultural sector: CH_4 emissions from enteric fermentation, direct N_2O emissions from agricultural soils and indirect N_2O emissions from agricultural soils.

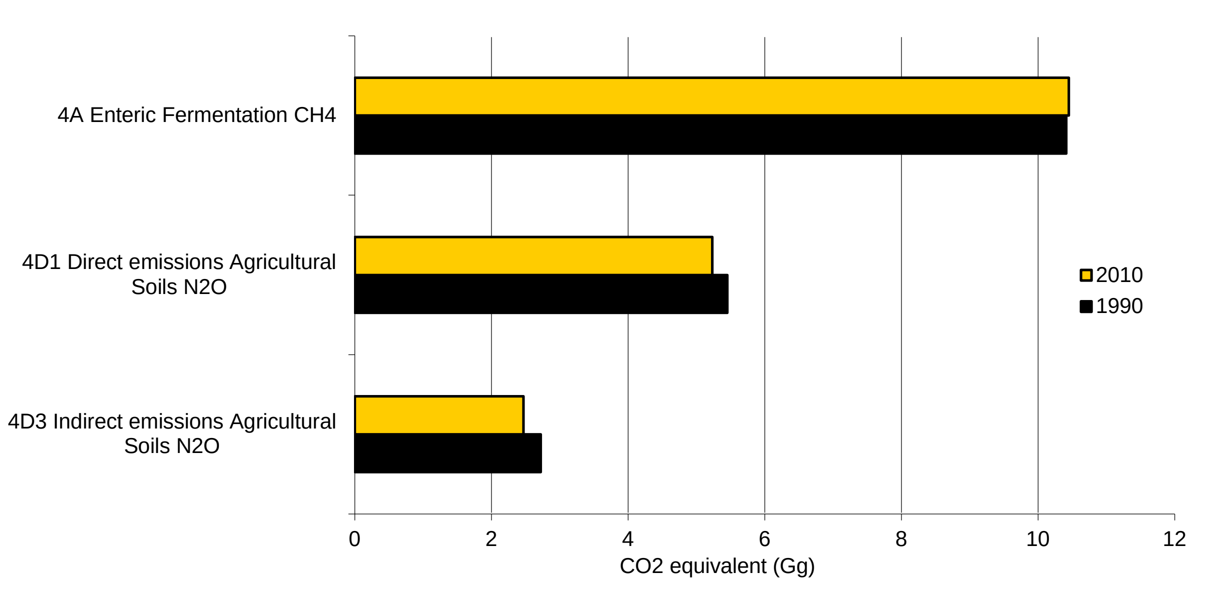


Figure 6-3 Key sources in agriculture. Emissions in CO_2 equivalents (Gg) per key source category in 2010 and in the base year 1990.

6.2 Source Category 4A – Enteric Fermentation

6.2.1 Source Category Description

Key source 4A
The CH_4 emissions from 4A Enteric Fermentation are a key source by level.

CH_4 emissions from enteric fermentation have decreased until 2000 and since then increased again to about the same level as 1990. They are basically following the cattle population number, as emissions from cattle contribute to 90% of the enteric fermentation emissions. A second development, the increasing productivity of the dairy cattle (high-yield cattle), results in a higher (per animal) emission factor and strengthens the incease in emissions after 2000.

Table 6-2 Specification of source category 4A “Enteric Fermentation”. AD: activity data; EF: emission factors.

4A	Source	Specification	Data Source
4A1	Cattle	Mature dairy cattle	AD: Livestock data from OFIVA/OA 2011 (since 2002), OA 2002 (before 2002) Net energy and metabolisable energy (calves) from RAP 1999. Categories according to Flisch et. al 2009 EF: Soliva 2006a
		Mature non-dairy cattle	
		Fattening Calves, Pre-Weaned Calves, Breeding Cattle 1st, 2nd, 3rd Year, Fattening cattle	
4A3 4A4	Sheep Goats		AD: Livestock data from OFIVA/OA 2011 (since 2002), OA 2002 (before 2002) Data on net energy and feed intake losses from SBV 2006 EF: Soliva 2006a
4A6 4A8	Horses Swine		AD: Livestock data from OFIVA/OA 2011 (since 2002), OA 2002 (before 2002) Data on digestible energy and feed intake losses from SBV 2006 EF: Soliva 2006a
4A7	Mules and asses		AD: Livestock data from OFIVA/OA 2011 (since 2002), OA 2002 (before 2002) Data on digestible energy and feed intake losses from SBV 2006 EF: Soliva 2006a
4A9	Poultry		AD: Livestock data from OFIVA/OA 2011 (since 2002), OA 2002 (before 2002) Data on metabolisable energy and feed intake losses from SBV 2006 EF: Hadorn and Wenk 1996 sited in Soliva 2006a.

6.2.2 Methodological Issues

6.2.2.1 Methodology

Liechtenstein adopted the Swiss calculation methodology, Tier 2, for CH_4 emissions in agriculture by applying the same calculation and therefore the same values for the gross energy intake (except for dairy and young cattle which are Liechtenstein specific) and by adjusting the activity data.

The following paragraph gives some further explanations about the Swiss calculation of CH_4 emissions from enteric fermentation *(excerpt from NIR CH, chpt. 6.2.2, FOEN 2011):*

The calculation is based on methods described in the IPCC Good Practice Guidance (IPCC 2000, equation 4.14). CH_4 emissions from enteric fermentation of the livestock population have been estimated using Tier 2 methodology. This means that detailed country specific data on nutrient requirements, feed intake and CH_4 conversion rates for specific feed types are required.

*For calculating the **gross energy intake** a country specific method based on available data on net energy (lactation, growth), digestible energy and metabolisable energy has been applied. Data on energy intakes are taken from SBV 2009 and from RAP 1999. The method is described in detail in Soliva 2006a and is realised in ART.*

Different energy levels (

Figure 6-4) are used to express the energy conversion from energy intake to the energy required for maintenance and performance.

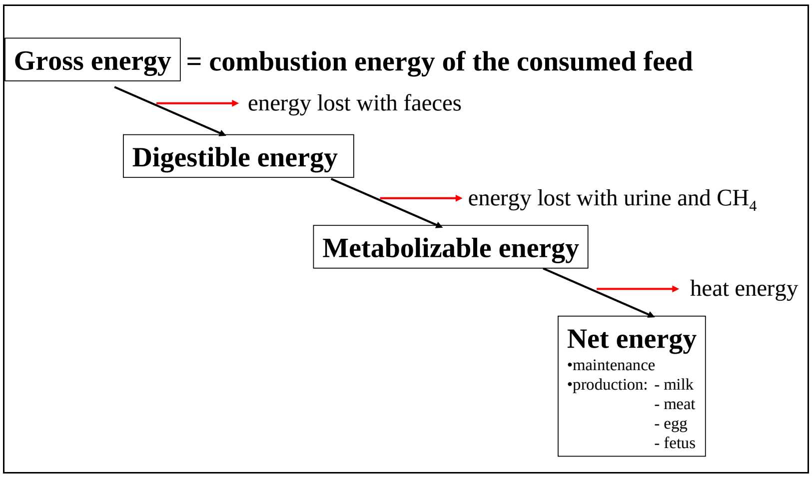


Figure 6-4 Levels of feed energy conversion. Reference: Soliva 2006a.

Net energy (NE) is used to express the energy required by the ruminants such as cattle, sheep and goats. NE in cattle feeding is further sub-divided into NE for lactation (NEL) and NE for growth (NEV). For some of the young cattle categories NEL is used rather than NEV what would seem natural. However, cattle raising is often coupled with dairy cattle activities and therefore the same energy unit (NEL) is used in these cases (RAP 1999). Exceptions are the fattening calves (milk-fed calves), whose requirements for energy are expressed as metabolisable energy (ME). Horses, mules, asses and swine are fed on the basis of digestible energy (DE), whereas poultry are fed according to metabolisable energy (ME).

In the energy estimation also some feed energy losses are integrated. Feed losses are defined as the feed not eaten by the animal and therefore represent a loss of net energy.

For the cattle categories detailed estimations for NE are necessary. As the Swiss Farmers Union (SBV) does not calculate the NE for detailed cattle source categories, NE data for each cattle subcategory was calculated individually according to the animal's requirements following the feeding recommendations of RAP (1999). These RAP recommendations are also used by the Swiss farmers as basis for their cattle feeding regime and for filling in application forms for subsidies for ecological services, and are therefore highly appropriate. In the calculation of the NE data, the animal's weight, daily growth rate, daily feed intake (dry matter), daily feed energy intake, and energy required for milk production for the respective source categories were considered (Soliva 2006a).

For estimating the gross energy intake out of the available data on net energy, metabolisable energy and digestible energy, the following conversion factors were applied:

6.2.2.2 Emission factors

All emission factors for enteric fermentation are country specific emission factors of Switzerland from the year 2011. They are based on IPCC equation 4.14 IPCC 2000, p. 4.26.

$$EF = \frac{GE * Y_m * 365\, days/y}{55.65\, MJ/kg\, CH_4}$$

GE: Gross energy intake

Y_m = Methane conversion rate, which is the fraction of gross energy in food converted to CH_4

55.65 MJ/kg = energy content of methane.

The following calculated gross energy intakes are used:

Table 6-3 Gross energy intake of different livestock groups. Calculation is based on the above mentioned parameters net energy, digestible energy, metabolisable energy according to the method described in FOEN 2011 and Soliva 2006a. Input data on net energy, digestible energy and metabolisable energy is taken from SBV 2009 and RAP 1999. Mature dairy cattle are are variable in time due to their dependency on milk production. All source categories displayed in italic.

Gross Energy intake		**1990-1999**									
		1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
		MJ/head/day									
Cattle											
Mature dairy cattle		282.1	282.6	284.3	285.5	281.7	283.7	284.1	287.9	290.6	292.0
Mature non-dairy cattle		*205.1*	*205.1*	*205.1*	*205.1*	*205.1*	*205.1*	*205.1*	*205.1*	*205.1*	*205.1*
Young cattle average		101.8	102.0	101.7	101.0	99.1	99.4	99.5	97.8	97.7	94.2
	Fattening Calves	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*
	Pre-Weaned Calves	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*
Sheep		22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6
Goats		31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4
Horses		137.4	137.4	137.4	137.4	137.4	137.4	137.4	137.4	137.4	137.4
Mules and Asses		100.2	100.2	100.2	100.2	100.2	100.2	100.2	100.2	100.2	100.2
Swine		35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1
Poultry 1)		1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2

1) Poultry data is not Gross Energy (GE) intake but Metabolizable Energy intake (ME)

Gross Energy intake		**2000-2009**									
		2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
		MJ/head/day									
Cattle											
Mature dairy cattle		296.4	303.6	305.5	306.3	311.4	308.9	307.9	307.6	309.3	304.4
Mature non-dairy cattle		*205.1*	*205.1*	*205.1*	*205.1*	*205.1*	*205.1*	*205.1*	*205.1*	*205.1*	*205.1*
Young cattle average		99.8	97.2	100.6	99.7	96.9	97.4	96.7	94.7	95.3	96.3
	Fattening Calves	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*
	Pre-Weaned Calves	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*
Sheep		22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6
Goats		31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4
Horses		137.4	137.4	137.4	137.4	137.4	137.4	137.4	137.4	137.4	137.4
Mules and Asses		100.2	100.2	100.2	100.2	100.2	100.2	100.2	100.2	100.2	100.2
Swine		35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1
Poultry 1)		1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2

Gross Energy intake		
		2010
Cattle		
Mature dairy cattle		304.4
Mature non-dairy cattle		*205.1*
Young cattle average		97.6
	Fattening Calves	*47.6*
	Pre-Weaned Calves	*55.7*
Sheep		22.6
Goats		31.4
Horses		137.4
Mules and Asses		100.2
Swine		35.1
Poultry 1)		1.2

The gross energy intake per head for mature dairy cattle increased until 2004 which is mainly a result of higher milk production and follows the development of the milk production per head (see Table 6-4). The gross energy intake of young cattle was calculated separately for all source categories (Breeding Cattle 1^{st}, 2^{nd}, 3^{rd} Year, Fattening Cattle, Fattening Calves, Pre-Weaned Calves) and subsequently averaged. Not all these source categories are displayed in Table 6-3. The values for all source categories summarized under young cattle are constant over time but since the composition of the young cattle category is changing over time, the average gross energy intake for young cattle is changing over time. The gross energy intake for mature non-dairy cattle is significantly higher than IPCC default values, since this category only comprehends of mature cows to produce offspring for meat. Milk production of this mature non-dairy cattle is 2500kg per head and year and does not change over the inventory time period (RAP 1999).

The energy intake for all other categories is estimated to be constant.

Statistics of annual milk production in Table 6-4 are from OFIVA/OA 2011 and build the basis for the calculation of the GEI of dairy cattle.

Table 6-4 Population size, lactation period and milk yield per animal 1990-2010

Milk production mature dairy cattle		**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Population size mature dairy cattle	head	2'850	2'843	2'747	2'601	2'677	2'643	2'652	2'622	2'614	2'589
Lactation period	day	305	305	305	305	305	305	305	305	305	305
Milk yield mature dairy cattle	kg/head/day	18.99	19.05	19.26	19.41	18.94	19.19	19.23	19.70	20.02	20.19
Milk yield mature non-dairy cattle	kg/head/day	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20

Milk production mature dairy cattle		**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Population size mature dairy cattle	head	2'440	2'639	2'560	2'543	2'460	2'489	2'589	2'593	2'579	2'565
Lactation period	day	305	305	305	305	305	305	305	305	305	305
Milk yield mature dairy cattle	kg/head/day	18.99	21.60	21.83	21.93	22.54	22.24	22.11	22.09	22.29	21.70
Milk yield mature non-dairy cattle	kg/head/day	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20

Milk production mature dairy cattle		**2010**
Population size mature dairy cattle	head	2'425
Lactation period	day	305
Milk yield mature dairy cattle	kg/head/day	21.70
Milk yield mature non-dairy cattle	kg/head/day	8.20

For the **methane conversion rate Ym** (%) only few country specific data exist. Therefore default values recommended by the IPCC for developed countries in Western Europe were used (IPCC 1997b: Reference Manual: p. 4.32–4.35 and IPCC 2000: p. 4.27). For poultry a Swiss country specific value ($Y_{poultry}$ = 0.1631) was used since no default value is given by the IPCC. This value was evaluated in an in vivo trial with broilers (Hadorn and Wenk 1996).

6.2.2.3 Activity data

The activity data input has been obtained from Liechtenstein's Office for Food-control and Veterinary (Amt für Lebensmittelkontrolle und Veterinärwesen) in cooperation with the Office for Agriculture (OFIVA/OA 2011, for all years since 2002) and from the Office of Agriculture (OA 2002, for the years before 2002).

Data for the livestock categories Mature Dairy Cattle, Sheep, Goats and Swine are available annually for the whole time series. For all the other livestock categories and it's source categories, data from the years 1990, 2000 and from 2002 on is available. Data in between was interpolated. Since 2002 data for all livestock categories is available on an annual basis. Livestock data is collected each year in March.
The disaggregtion into the various sub categories (young cattle and young swine) and the time-series consistency between the data from different sources (OA 2002 and OFIVA/OA 2011) has been improved in the Recalculation of the Agriculture sector for this Submission (OEP 2011b).

Table 6-5 Activity Data for Liechtenstein (OFIVA/OA 2011, OA 2002). Head numbers are used to calculate CH_4 emissions, while animal place numbers are used to calculate N_2O emissions.

Population Size											
		1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	Head/Places										
Fattening Calves	places	50	56	62	69	75	81	87	93	100	106
Pre-Weaned Calves	head	15	18	23	26	31	35	38	43	46	51
Breeding Cattle 1st Year	head	1'136	1'027	1'020	935	1'030	1'057	994	1'011	917	965
Breeding Cattle 2nd Year	head	903	815	794	694	668	699	719	627	572	513
Breeding Cattle 3rd Year	head	631	619	632	572	509	575	494	460	457	360
Fattening Cattle	places	723	801	704	742	812	725	869	822	720	440
Young Cattle	head	3'458	3'336	3'235	3'038	3'125	3'172	3'201	3'056	2'812	2'435
Mature Dairy Cattle	head	2'850	2'843	2'747	2'601	2'677	2'643	2'652	2'622	2'614	2'589
Mature Non-Dairy Cattle	head	20	25	31	36	42	47	52	58	63	69
Total Cattle	**head**	**6'328**	**6'204**	**6'013**	**5'675**	**5'844**	**5'862**	**5'905**	**5'736**	**5'489**	**5'093**
Fattening Sheep	places	1'636	1'765	1'755	1'685	1'551	1'079	2'127	2'114	2'240	2'108
Milksheep	places	0	0	0	0	0	0	0	0	0	0
Total Sheep	**head**	**2'781**	**2'689**	**2'878**	**2'641**	**2'627**	**2'632**	**3'352**	**3'234**	**3'608**	**3'264**
Goat Places	places	111	154	179	103	84	100	197	193	209	190
Total Goats	**head**	**171**	**213**	**277**	**181**	**136**	**145**	**275**	**269**	**287**	**313**
Horses <3 years	head	33	32	30	29	28	27	25	24	23	21
Horses >3 years	head	133	133	134	134	134	135	135	135	135	136
Total Horses	**head**	**166**	**165**	**164**	**163**	**162**	**162**	**160**	**159**	**158**	**157**
Total Mules and Asses	**head**	**73**	**71**	**85**	**113**	**111**	**133**	**159**	**166**	**184**	**197**
Piglets	places	506	495	484	474	463	452	441	430	420	409
Fattening Pig over 25 kg	places	1'006	1'251	978	791	1'080	1'091	253	151	161	151
Dry Sows	places	207	298	245	173	154	191	120	282	192	233
Nursing Sows	places	66	96	79	55	50	62	38	91	62	75
Boars	head	5	5	5	5	5	5	4	4	4	4
Total Swine	**head**	**3'251**	**3'543**	**2'902**	**3'236**	**2'787**	**2'429**	**2'392**	**2'128**	**2'056**	**2'122**
Growers	places	105	95	84	74	63	53	42	32	21	11
Layers	places	4'145	4'417	4'689	4'961	5'233	5'506	5'778	6'050	6'322	6'594
Broilers	places	0	100	200	300	400	500	600	700	800	900
Turkey	places	22	29	35	42	48	55	61	68	74	81
Other Poultry (Geese, Ducks, Ostriches,	places	163	157	152	146	140	134	129	123	117	111
Total Poultry	**head**	**4'435**	**4'798**	**5'160**	**5'523**	**5'884**	**6'248**	**6'610**	**6'973**	**7'334**	**7'697**

Population Size											
		2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	Head/Places										
Fattening Calves	places	112	92	71	89	87	83	63	106	80	104
Pre-Weaned Calves	head	11	56	101	141	252	266	283	339	341	294
Breeding Cattle 1st Year	head	649	746	645	595	630	601	717	688	724	723
Breeding Cattle 2nd Year	head	544	510	626	631	605	676	668	683	659	727
Breeding Cattle 3rd Year	head	343	358	413	383	384	348	398	315	372	372
Fattening Cattle	places	774	496	659	707	776	743	703	839	838	860
Young Cattle	head	2'433	2'258	2'515	2'546	2'734	2'717	2'832	2'970	3'014	3'080
Mature Dairy Cattle	head	2'440	2'639	2'560	2'543	2'460	2'489	2'589	2'593	2'579	2'565
Mature Non-Dairy Cattle	head	74	112	149	199	279	362	405	466	454	433
Total Cattle	**head**	**4'947**	**5'009**	**5'224**	**5'288**	**5'473**	**5'568**	**5'826**	**6'029**	**6'047**	**6'078**
Fattening Sheep	places	1'522	2'117	1'681	1'697	1'911	2'005	2'049	2'064	2'090	2'081
Milksheep	places	0	0	0	0	0	41	51	0	0	0
Total Sheep	**head**	**2'983**	**3'319**	**3'116**	**3'070**	**3'149**	**3'063**	**3'687**	**3'683**	**3'850**	**3'963**
Goat Places	places	96	147	129	130	155	171	198	179	251	266
Total Goats	**head**	**164**	**210**	**205**	**241**	**286**	**324**	**362**	**319**	**425**	**452**
Horses <3 years	head	20	12	4	11	24	28	32	28	24	30
Horses >3 years	head	136	162	187	196	230	237	253	249	277	282
Total Horses	**head**	**156**	**174**	**191**	**207**	**254**	**265**	**285**	**277**	**301**	**312**
Total Mules and Asses	**head**	**223**	**250**	**153**	**140**	**160**	**144**	**141**	**164**	**193**	**189**
Piglets	places	398	322	246	268	7	222	267	192	218	147
Fattening Pig over 25 kg	places	1'229	103	1'506	1'484	962	1'162	1'019	1'125	1'098	1'179
Dry Sows	places	91	217	85	102	5	96	76	78	79	98
Nursing Sows	places	22	70	21	15	3	21	32	29	29	29
Boars	head	4	4	4	3	1	3	4	3	4	3
Total Swine	**head**	**1'992**	**2'248**	**2'101**	**2'029**	**990**	**1'703**	**1'723**	**1'735**	**1'758**	**1'811**
Growers	places	0	0	0	11	9	0	9	1	48	0
Layers	places	6'866	8'450	10'034	10'113	10'549	10'112	11'398	11'357	11'766	11'650
Broilers	places	1'000	625	250	250	520	250	300	702	350	350
Turkey	places	87	94	100	34	52	52	35	164	15	3
Other Poultry (Geese, Ducks, Ostriches,	places	106	100	0	2	25	39	127	166	229	165
Total Poultry	**head**	**8'059**	**9'269**	**10'384**	**10'410**	**11'155**	**10'453**	**11'869**	**12'390**	**12'408**	**12'168**

(Cont'd next page)

Population Size		
		2010
Fattening Calves	places	81
Pre-Weaned Calves	head	281
Breeding Cattle 1st Year	head	814
Breeding Cattle 2nd Year	head	808
Breeding Cattle 3rd Year	head	459
Fattening Cattle	places	743
Young Cattle	head	3'186
Mature Dairy Cattle	head	2'425
Mature Non-Dairy Cattle	head	382
Total Cattle	**head**	**5'993**
Fattening Sheep	places	2'061
Milksheep	places	0
Total Sheep	**head**	**3'656**
Goat Places	places	253
Total Goats	**head**	**434**
Horses <3 years	head	31
Horses >3 years	head	304
Total Horses	**head**	**335**
Total Mules and Asses	**head**	**154**
Piglets	places	301
Fattening Pig over 25 kg	places	1'058
Dry Sows	places	101
Nursing Sows	places	18
Boars	head	3
Total Swine	**head**	**1'690**
Growers	places	61
Layers	places	12'175
Broilers	places	390
Turkey	places	103
Other Poultry (Geese, Ducks, Ostriches,	places	191
Total Poultry	**head**	**12'920**

The number of sheep, goats and horses increased between 1990 and 2010.
The massive increase in the poultry population is a result of two new poultry farms that were established in Liechtenstein but seem to have reached a stable population since 2007.
The drastic decrease of the swine population between 2003 and 2004 was caused by a disease, since 2005 number of swine remains rather constant.
Total number of cattle decreased by 22% between 1990 and the beginning of the new century, but is growing again continuously since 2003. Mature non-dairy cattle (mature cows used to produce offspring for meat) are increasing on a low level, as this form of meat production and cattle breeding is relatively new.

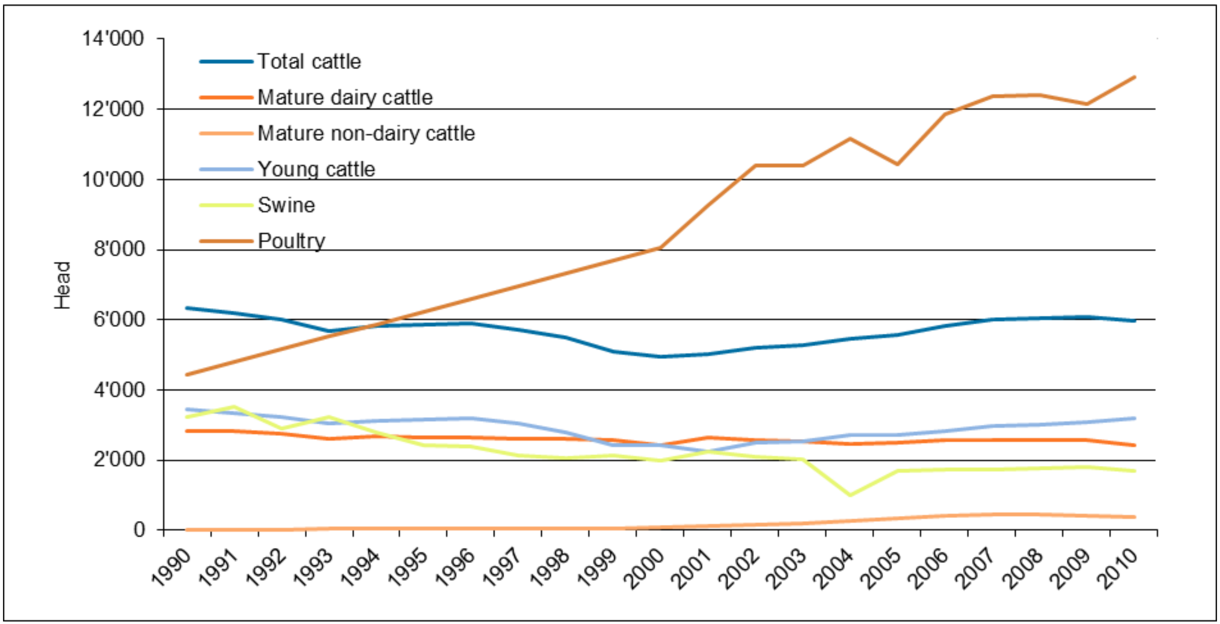


Figure 6-5 Development of population size of main animal categories 1990-2010 (OFIVA/OA 2011)

6.2.3 Uncertainties and Time-Series Consistency

For the uncertainty analysis the following input data from the Swiss Agroscope Reckenholz-Tänikon Research Station ART was used (ART 2008). It is assumed that uncertainty estimations from Switzerland are also applicable for Liechtenstein. Liechtenstein applies the same methods and emission factors and has a similar sophisticated livestock data collection system with low inaccuracies.

Table 6-6 Input data for the uncertainty analysis of the source category 4A “Enteric Fermentation” (ART 2008).

Input data for uncertainty analysis 4A	**Lower bound (2.5 Percentile)**	**Upper bound (97.5 Percentile)**	**Mean uncertainty**
Activity data (head)	-6.4%	+6.4%	±6.4%
Emission factor (kg CH_4 /head/yr)	-14.7%	+19.6%	±17.2%

To apply for the Tier 1 uncertainty analysis, the arithmetic mean of lower and upper bound is used for activity data and for emission factors. For further results see Section 1.7.

Time series between 1990 and 2010 is consistent.

6.2.4 Source-Specific QA/QC and Verification

In the Agriculture sector special source-specific QA/QC activities have been carried out. A major revision of the background calculation model has been done in cooperation with an external Swiss agriculture expert, based on the Swiss Methodology in FOEN (2011) and with Liechtenstein specific adaptions (OEP 2011b).
Also, as mentioned in sections 1.6.1.4 and 1.6.1.5, the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010) has been executed, and changes compared to Submission 2011 had to be retraced to the changes caused by the major revision.

Documentation of the new calculation method adapted from Switzerland assures transparency and traceability of the calculation methods and data sources (OEP 2011b, FOEN 2011). A quality control was done by Acontec and INFRAS by a countercheck of the calculation sheets.

The SE, the NIC and the NIR author report their QC activities in a checklist (see Annex 8).

6.2.5 Source-Specific Recalculations

For 2009, the difference is 0.435 Gg CO_2 eq (+4.2%) compared to Submission 2011. These differences appear mainly due to a major recalculation of Liechtenstein's methodology and a reassessment of the activity data for young cattle for the whole time series. Basically, activity data coherency was improved in cooperation with Liechtenstein's Office for Agriculture, as different census methodologies were used before 2002 and after (OA 2011b).

Also a recalculation of milk production by mature dairy cattle has been conducted leading to considerably higher values for the years 1999 – 2010. Additionally gross energy intake rates of the young cattle categories "breeding cattle 1st year" (includes breeding calves and breeding cattle 4-12 months) and "fattening cattle" (includes fattening calves 0-4 months and fattening cattle 4-12 months) have been revised, in order to reflect the annual animal husbandry regime more realistically. Both of these recalculations contributed to a considerable higher gross energy intake of the total cattle population and hence to higher emission estimates for enteric fermentation than in previous submissions. Furthermore, the energy intake calculation of poultry has been changed using metabolizable energy rather than gross energy as basis for emission factor calculation (according to Hadorn and Wenk 1996) leading to lower values for the whole time series (OA 2011b)

Also, following FCCC/ARR (2010a), "breeding cattle" is now reported the CRF tables under the relevant cattle group an not under "other".

6.2.6 Source-Specific Planned Improvements

There are no further source-specific improvements planned.

6.3 Source Category 4B – Manure Management

6.3.1 Source Category Description

Key source 4B
Source category 4B Manure Management CH_4 and N_2O **are not** key sources.

CH_4 and N_2O emissions from manure management 2010 are 1.2% lower than the emissions in 1990. The emissions of manure management follow closely the development of the cattle population.

Table 6-7 Specification of source category 4B “Manure Management (CH_4)”. AD: Activity data; EF: Emission factors.

4B	Source	Specification	Data Source
4B1	Cattle	Mature dairy cattle	AD: OFIVA/OA 2011 (since 2002), OA 2002 (before 2002) EF: IPCC 2000; IPCC 1997c; Soliva 2006a; Flisch et al. 2009; Agrammon 2010;
		Mature non-dairy cattle	
		Fattening Calves, Pre-Weaned Calves, Breeding Cattle 1st, 2nd, 3rd Year, Fattening cattle	
4B3 4B4 4B6 4B8	Sheep Goats Horses Swine		AD: OFIVA/OA 2011 (since 2002), OA 2002 (before 2002) EF: IPCC 2000; IPCC 1997c; Soliva 2006a; Flisch et al. 2009; Agrammon 2010;
4B7	Mules and Asses		AD: OFIVA/OA 2011 (since 2002), OA 2002 (before 2002) EF: IPCC 2000; IPCC 1997c; Soliva 2006a; Flisch et al. 2009; Agrammon 2010;
4B9	Poultry		AD: OFIVA/OA 2011 (since 2002), OA 2002 (before 2002) EF: IPCC 2000; IPCC 1997c; Soliva 2006a; Flisch et al. 2009; Agrammon 2010;

Table 6-8 Specification of source category 4B “Manure Management (N_2O)”. AD: Activity data; EF: Emission factors.

4B	Source	Specification	Data Source
4B11 4B12	Liquid Systems Solid storage and dry lot		AD: OFIVA/OA 2011 (since 2002), OA 2002 (before 2002); Flisch et. al 2009; Agrammon 2010. EF: IPCC 2000; IPCC 1997c

6.3.2 Methodological Issues

Liechtenstein adopted the Swiss calculation methodology, Tier 2, for emissions from manure management by adjusting the activity data.

For calculation of CH_4 and N_2O emissions slightly different livestock source categories are used. The livestock categories reported in the CRF tables are the same, but the respective source categories as a basis for the calculation are slightly different. Nevertheless there is no inconsistency in the total number of animals as they are the same both for CH_4 and N_2O emissions.

Calculation of CH_4 emissions of enteric fermentation is based on the head number of the livestock, while calculation of N_2O emissions is based on a slightly different livestock population break down based on animal places (see Table 6-5).

The following paragraph gives some further explanations about the reason for the Swiss specific calculation of N_2O emissions from manure management *(excerpt from NIR CH, chpt. 6.3.2, FOEN 2011):*

This calculation is chosen because more detailed data on N excretion for the particular animal categories are available (Flisch et al. 2009, Agrammon 2010). The nitrogen excretion rates are given on a yearly basis, considering replacement of animals (young cattle, swine and poultry) and including excretions from corresponding offsprings and other associated animals (sheep, goats, swine).

6.3.2.1 CH_4 Emissions

a) Methodology

Calculation of CH_4 emissions from manure management is based on IPCC Tier 2 (IPCC 2000, equation 4.17).

$$EF_i = VS_i \bullet 365\ days/year \bullet Bo_i \bullet 0.67\ kg/m^3 \bullet \sum_{ijk} MCF_{jk} \bullet MS_{ijk}$$

EF_i: annual emission factor for livestock population i
VS_i: daily VS excreted for an animal within population i
Bo_i: maximum CH_4 producing capacity for manure produced by an animal within population i
MCF_{jk}: CH_4 conversion factors for each manure management system j by climate region k
MS_{ijk}: fraction of animal species / category i's manure handled using manure system j in climate region k

b) Emission factor

Calculation of the emission factor is based on the parameters volatile substance excreted (VS), the maximum CH_4 producing capacity for manure (B_o) and the CH_4 conversion factors for each manure management system (MCF).

VS & DE (digestible energy): No country specific values for the daily excretion of VS & DE are available.
The VS and DE for cattle source categories are taken from Switzerland and based on IPCC (2000: equation 4.16: p. 4.31). Gross energy intake is calculated according to the method described in Chapter 6.2.2. For the categories breeding cattle 1st year and fattening cattle the resulting values differ slightly from the values in Switzerland, as they are a weighted mean[13] of the values of Swiss cattle subcategories (0-4 months and 5-12 months) as Liechtenstein's statistics do not contain this disaggregation level.
For the livestock categories swine, sheep, goats, horses, mules and asses, and poultry default values from IPCC 1997 (1997c: Reference Manual: p. 4.39 to 4.47) were taken.

The **ash content** of cattle manure is assumed to amount to 8% on average (IPCC 1997c: Reference Manual: p. 4.47).

B_o: For the Methane Producing Potential default values are used (IPCC 1997c: Reference Manual: p. 4.39 to 4.47).

MCF: For the Methane Conversion Factor IPCC default values are used (IPCC 2000, p. 4.36 and IPCC 1997c: Reference Manual: p. 4.25). In Liechtenstein mainly two manure management systems exist (AWMS), solid storage and liquid/slurry storage. Calves are mainly kept in deep litter systems and there are also specific MCF values for pasture and poultry systems: The following MCF's were used:

[13] Weighted by days (e.g. breeding cattle: 120 days for breeding calves, 225 days for breeding cattle)

Table 6-9 Manure management systems and Methane conversion factors (MCFs). References: IPCC 2000, p. 4.36 and IPCC 1997b: p. 4.25 (for liquid/slurry).

Manure management system	Description	MCF
Solid manure	Dung and urine are excreted in a barn. The solids (with and without litter) are collected and stored in bulk for a long time (months) before disposal.	1%
Liquid/slurry	Combined storage of dung and urine under animal confinements for longer than 1 month.	10%
Pasture	Manure is allowed to lie as it is, and is not managed (distributed, etc.).	1%
Deep litter	Dung and urine is excreted in a barn with lots of litter and is not removed for a long time (months). This is applied for the cattle source categories of milk-fed calves and fattening calves, and for sheep and goats.	10%
Poultry system	Manure is excreted on the floor with or without bedding.	1.5%

For the MCF for deep litter the 2000 IPCC good practice guidance suggest a value of 39%. However, this would lead to a rather large overestimation of methane emissions from deep litter manure management systems. Since the 2000 IPCC good practice guidance state that the MCF‘s for cattle and swine deep litter are similar to liquid/slurry, the respective value from the 1996 IPCC guidelines (IPCC 1997b) has been adopted. The choice of a MCF of 10% for deep litter is supported by a number of studies representative for the country specific management conditions (see Saturday Paper of Switzerland in Annex of FOEN 2011).

The fractions of animal’s manure handled using different manure management systems (**MS**) as well as the grazing time for each livestock category are based on Switzerland’s data from FOEN (2011), as the Swiss agriculture infrastructure is very similar to the on in Liechtenstein. The fractions for the year 2002 are applied constantly for the whole time series, as this was the year when Switzerland’s extensive farm survey took place (Agrammon ,2010). This approach with the constant value of 2002 seems to be justifiable, as the influence of the distribution to the different management systems on the total is negligible and no information on the development of the MS in Liechtenstein is available.

c) Activity data

Data on population sizes are taken from the Office of Food-control and Veterinary (OFIVA/OA 2011) and the Office of Agriculture (OA 2002). For details refer to chapter 6.2.2.

6.3.2.2 N_2O Emissions

a) Methodology

Liechtenstein follows the Swiss approach for calculating N_2O emissions from manure management with LIE specific AD.

The Swiss methodology is explained in the following paragraph (*excerpt from NIR CH, chpt. 6.3.2, FOEN 2011):*

For the calculation of N_2O emissions from manure management a country specific method based on the new Swiss ammonia model AGRAMMON is applied (Agrammon 2010). Basically the IPCC emission factors are used, but activity data is adjusted to the particular situation of Switzerland.

For calculation of emissions from manure management AGRAMMON applies other values for the nitrogen excretion per animal category than IPCC and differentiates the animal waste management systems Liquid systems and Solid storage.

b) Emission factors

IPCC default emission factors are used for the two animal waste management systems occurring in Liechtenstein (IPCC 1997c: Reference Manual: p. 4.104). N_2O emissions from pasture, range and paddock appear under the category „4D: Agricultural soils, subcategory 2 animal production. IPCC categories „daily spread— and „other systems— are not occurring. The basic animal waste management systems are defined in Menzi et al. (1997).

Table 6-10 Emission factors for calculating N_2O emissions from manure management (IPCC 1997c: p. 4.104).

Source	**Emission factor per animal waste management system (kg N_2O-N / kg N)**
Liquid systems	0.001
Solid storage	0.020

In particular the following values have been adopted from the Swiss Ammonia model Agrammon (2010) of the Swiss Inventory (FOEN 2011): $MS_{Pasture}$, $MS_{Solid\ Storage}$, $MS_{Liquid\ System}$, $NH_{3\ Pasture}$, $NH_{3\ Housing}$, $NH_{3\ Storage}$, $NH_{3\ Application}$.

c) Activity data

Input data on all livestock groups are taken from OFIVA/OA 2011 and OA 2002. Data are converted into animal place number for certain livestock categories (see Table 6-5).

Except for dairy cattle, which is calculated based on country specific milk production data according to the methodology of Flisch et. al (2009), no national data on nitrogen excretion per animal category (kg N/head/year) is available in Liechtenstein. Therefore Swiss data is taken from the Swiss Ammonia model Agrammon (2010). Unlike IPCC, the age structure of the animals and the different use of the animals (e.g. fattening and breeding) are considered. Sheep are estimated to excrete approximately 8.0 kg N per head and year, which is considerably lower then IPCC default. However, nitrogen excretion is averaged over the whole population of which roughly 50% are lambs and other immature animals. Furthermore, sheep are fed mainly according to a regime based on roughage from extensive pasture and meadows (Flisch et al. 2009). Swine show a significant decrease in nitrogen excretion per head which can be explained by the increasing use of protein reduced fodder.

The consideration of adopted nitrogen excretion values is one of the major advantages of the Swiss country specific method adopted in Liechtenstein's Inventory. The more disaggregated approach results in considerable lower calculated nitrogen excretion rates compared to IPCC, which therefore also implies lower total N_2O emissions from manure management

Table 6-11 Nitrogen exrection per animal category (kg N/head/year) in five year steps 1990 -2010 (Agrammon 2010, except for dairy cattle).

Nitrogen excretion	**1990-2010**				
	1990	**1995**	**2000**	**2005**	**2010**
	kg N / head / year				
Cattle					
Mature dairy cattle	107.71	108.37	111.77	114.31	113.39
Mature non-dairy cattle	80.00	80.00	80.00	80.00	80.00
Young cattle	35.93	35.37	34.62	35.28	34.62
Fattening Calves	13.00	13.00	13.00	13.00	13.00
Pre-Weaned Calves	34.00	34.00	34.00	34.00	34.00
Breeding Cattle 1st Year	25.00	25.00	25.00	25.00	25.00
Breeding Cattle 2nd Year	40.00	40.00	40.00	40.00	40.00
Breeding Cattle 3rd Year	55.00	55.00	55.00	55.00	55.00
Fattening Cattle	33.00	33.00	33.00	33.00	33.00
Sheep	8.82	6.15	7.65	10.10	8.46
Fattening Sheep	15.00	15.00	15.00	15.00	15.00
Milk Sheep	21.00	21.00	21.00	21.00	21.00
Goats	10.39	11.03	9.37	8.44	9.33
Goat places	16.00	16.00	16.00	16.00	16.00
Horses	43.60	43.67	43.74	43.79	43.81
Horses < 3 years	42.00	42.00	42.00	42.00	42.00
Horses > 3 years	44.00	44.00	44.00	44.00	44.00
Mules and Asses	15.70	15.70	15.70	15.70	15.70
Swine	6.96	9.47	10.40	11.19	10.67
Piglets	4.63	4.63	4.63	4.63	4.63
Fattening Pig over 25 kg	13.00	13.00	13.00	13.00	13.00
Dry Sows	20.00	20.00	20.00	20.00	20.00
Nursing Sows	45.36	45.36	45.36	45.36	45.36
Boars	18.00	18.00	18.00	18.00	18.00
Poultry	0.70	0.68	0.68	0.71	0.70
Growers	0.34	0.34	0.34	0.34	0.34
Layers	0.71	0.71	0.71	0.71	0.71
Broilers	0.40	0.40	0.40	0.40	0.40
Turkey	1.40	1.40	1.40	1.40	1.40
Other Poultry (Geese, Ducks, Ostriches, Quails)	0.56	0.56	0.56	0.56	0.56

The split of nitrogen flows into the different animal waste management systems is the split occurring in the year 2002 in Switzerland according to latest Swiss Inventory (FOEN 2011) and based on Agrammon (2010). It is constant over time, due to the lack of specific data in Liechtenstein. This approach is justifiable, as the influence of the distribution on total Emissions is negligible according to estimation with Swiss data (OEP 2011b).
After the major revision the distribution of the nitrogen flows is now consistent with the allocation of volatile solids used for the calculation of CH_4 emissions (see Chapter 6.3.2.1.)

6.3.3 Uncertainties and Time-Series Consistency

For the uncertainty analysis the following input data from the Swiss Agroscope Reckenholz-Tänikon Research Station ART was used (ART 2008):

Table 6-12 Input data for the uncertainty analysis of the source category 4B “Manure Management”. (ART 2008).

Input data for uncertainty analysis 4B	Lower bound (2.5 Percentile	Upper bound (97.5 Percentile)	Mean uncertainty
Activity data CH_4 (head)	-6.4%	+6.4%	±6.4%
Activity data N_2O (liquid systems and solid storage, kg N)	-29.9%	+29.2%	±29.5%
Emission factor CH_4 (kg CH_4 /head/yr)	-54.7%	+53.6%	±54.1%
Emission factor N_2O (liquid systems, kg N_2O-N / kg N)	-100%	+0%	±50%
Emission factor N_2O (solid storage, kg N_2O-N / kg N)	-75%	+50%	±62.5%

It is assumed that uncertainty estimations from Switzerland are also applicable for Liechtenstein. Liechtenstein applies the same methods and emission factors and has since 2002 a sophisticated and livestock data collection system with low inaccuracies.

To apply for the Tier 1 uncertainty analysis, the arithmetic mean of lower and upper bound is used for activity data and for emission factors. For further results see Section 1.7.

For further results see Section 1.7. The time series 1990-2010 is consistent.

6.3.4 Source-Specific QA/QC and Verification

In the Agriculture sector special source-specific QA/QC activities have been carried out. A major revision of the background calculation model has been implemented in cooperation with an external Swiss agriculture expert, based on the Swiss Methodology in FOEN (2011) and with Liechtenstein specific adaptions (OEP 2011b).

Also, as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010) has been executed and changes compared to the submission 2011 had to be retraced to the changes caused by the major revision.

Documentation of the new calculation method adapted from Switzerland assures transparency and traceability of the calculation methods and data sources (OEP 2011b, FOEN 2011). A quality control was done by Acontec and INFRAS by a countercheck of the calculation sheets. A quality control was done by Acontec and INFRAS by a countercheck of the calculation sheets.

The SE, the NIC and the NIR author report their QC activities in a checklist (see Annex 8).

6.3.5 Source-Specific Recalculations

The ERT questioned that the allocation of the nitrogen excreted to the different AWMS (questions Q5, Q8 and Q13, and Para 63 in the FCCC/ARR 2010) have led to an internal review and subsequent revision of the calculation sheets (OEP 2011b). The party has found out that a major recalculation in this sector was necessary, as the total quantity of nitrogen was incorrectly allocated to the different AWMS. Along with this improvement, the recalculated Swiss MCF for deep litter (FOEN 2011) was incorporated.

6.3.6 Source-Specific Planned Improvements

There are no further source-specific improvements planned.

6.4 Source Category 4C – Rice Cultivation

Rice Cultivation does not occur in Liechtenstein.

6.5 Source Category 4D – Agricultural Soils

6.5.1 Source Category Description

Key source 4D1, 4D3
Direct (4D1) N_2O emissions from agricultural soils are key sources by level.
Indirect (4D3) N_2O emissions from agricultural soils are key sources by level.

The source category 4D includes the following emissions: Direct N_2O emissions from soils, from animal production and indirect N_2O, NO_x and NMVOC emissions from agricultural soils.

In general, direct and indirect N_2O emissions have decreased 2010 compared to 1990 by 4.4% mainly due to a reduction of the number of cattle and a reduced input of mineral fertilizers. The lowest N_2O emission level was 2000. Since then, total emissions are slightly increasing most probably because of newly increasing cattle numbers (see figure Figure 6-5).

Table 6-13 Specification of source category 4D “Agricultural Soils”. (AD: Activity data; EF: Emission factors).

4D	Source	Specification	Data Source
4D1	Direct soil emissions	Includes emissions from synthetic fertilizer, animal manure, crop residue, N-fixing crops, organic soils, residues from pasture range and paddock, N-fixing pasture range and paddock	AD: OA 2000, OA 2011, FAL/RAC 2001, Flisch et al. 2009, Agrammon 2010, , Leifeld et al. 2003, Schmid et al. 2000, Walther et al. 1994 EF: IPCC 1997c (N_2O); IPCC 2000
4D2	Pasture, range and paddock manure	Only emissions from pasture, range and paddock	AD: OA 2011, Flisch et al. 2009, Agrammon 2010 EF: IPCC 1997c
4D3	Indirect emissions	Leaching and run-off, N deposition air to soil	AD: OA 2011, Flisch et al. 2009; Agrammon 2010, Prasuhn and Braun 1994, Braun et al. 1994, Schmid et al. 2000 EF: IPCC 2000

6.5.2 Methodological Issues

6.5.2.1 Methodology

Liechtenstein applies the latest Swiss method of IULIA for calculating N_2O emissions from soils, because of the comparable agricultural situation in Liechtenstein with the same composition of soils and its agricultural management. Activity data is Liechtenstein specific. The methodology as well as differences between IULIA and the IPCC method are described in the following paragraph *(excerpt from NIR CH, chpt. 6.5.2, FOEN 2011):*

IULIA is an IPCC-derived method for the calculation of N_2O emissions from agriculture that basically uses the same emission factors, but adjusts the activity data to the particular situation of Switzerland (Schmid et al. 2000). According to Schmid et al. (2000) IULIA is better adapted to the conditions of Swiss agriculture, compared to the IPCC method. There is no indication that the adoption of the IPCC method would lead to a better estimation of the N_2O emissions in Switzerland.

IULIA has been updated in 2010 with new parameters derived from the Swiss ammonium model AGRAMMON (Agrammon 2010). New values for nitrogen excretion, manure system distribution and ammonium emission factors have been adopted

Main differences between the IULIA method and IPCC are (Schmid et al. 2000, p. 74):

- *IULIA estimates lower nitrogen excretion per animal category, especially due to the lower excretions of cattle*
- *The amount of losses to the atmosphere from the excreted nitrogen is more than 50% higher compared to IPCC.*
- *The amount of leaching (of nitrogen excreted and of synthetic fertilizers) is lower by 1/3 compared to IPCC.*
- *The share of solid storage out of the total manure is twofold; the share of excretion on pasture, range and paddock has been ½ in 1990 and has almost doubled thereafter reaching IPCC default values.*
- *The nitrogen inputs from biological fixation are higher by a factor of 30 since fixation on meadows and pastures are also considered. The consideration of nitrogen fixation from grassland is one of the major advantages of the method IULIA as the grassland accounts for the majority on nitrogen fixed in Swiss agricultural soils.*
- *The nitrogen inputs from crop residues are only 25% higher although emissions from plant residue on grasslands are considered. This is explained by the fact that the emissions from plant residues returned to soils on cropland are estimated 50% below the IPCC defaults.*

Despite the different assumptions of the two methods, differences at the level of the N_2O emissions are quite moderate. In total IULIA estimations of the N_2O emissions from agriculture are 15% lower than the IPCC estimations (Schmid et al. 2000, p. 75).

Direct emissions from soil (4D1):

Calculation of direct N_2O emissions from soil is based on IPCC 2000 Tier 1b. Liechtenstein follows the Swiss method IULIA with using national activity data.

- Emissions from **synthetic fertilizer** include mineral fertilizer, compost and sewage sludge. From the amount of nitrogen in fertilizer, losses to the atmosphere in form of NH_3 are subtracted and the rest is multiplied by the corresponding emission factor. According to AGRAMMON losses to the atmosphere are 15% for urea and 2% for other synthetic fertilizers instead of the IPCC value of 10% for NH_3 and NO_x. (Agrammon 2010). The $Frac_{GASF}$ has declined considerably due to a reduction of the use of urea and sewage sludge which both have high NH_3 emission factors. NO_x emissions are not subtracted since they occur mainly after the fertilizer application. The basis for N_2O-emissions is the mineral fertilizer including the nitrogen that will be lost as NO_x later (Berthoud 2004).

- To model the emissions of **animal manure applied to soils,** nitrogen input from manure applied to soils is calculated. This is calculated by the total N excretion minus N excreted on pastures minus NH_3 volatilization from solid and liquid manure. Following AGRAMMON the losses (to the atmosphere) as ammonia are specified for each management category instead of using a fixed ratio of 20% (Agrammon 2010). NO_x emissions are not subtracted since they occur after the application of animal wastes. For details regarding the volatized N refer to Table 6-15.

- Emissions from **crop residues** are based on the amount of nitrogen in crop residues returned to soil. According to IULIA (Schmid et al. 2000, p. 68 and p. 100) the calculation of nitrogen in crop residues is based on data reported on crop yields in Liechtenstein, the standard values for arable crop yields for Switzerland and standard amounts of nitrogen in crop residues returned to soils for Switzerland (Flisch et. al 2009). The calculation of the amount of nitrogen in crop residues returned to soil according to IULIA is as follows (Schmid et al. 2000, p. 101):

$$F_{CR} = \sum_{Cr} (E_{Cr} * \frac{NR_{Cr}}{Y_{Cr}})$$

F_{CR}: Amount of nitrogen in crop residues returned to soils (t N)
E_{Cr}: Amount of crop yields for culture Cr (t)
Y_{Cr}: Standard values for arable crop yields for culture Cr (t/ha)
NR_{Cr}: Standard amount of nitrogen in crop residues returned to soils (t/ha)

From 2001 on updated standard values and amounts of nitrogen returned to soil are used. In addition to the N transfer from crop residues, IULIA also takes into account the plant residue returned to soils on meadows and pastures (Schmid et al. 2000). The grassland area in Liechtenstein is almost as big as the agricultural land. Input data on the managed area of meadows and pastures are taken from (OA 2011).

- For calculation of emissions from **N-fixing crops**, IULIA assumes that 60% of the nitrogen in crops is caused by biological nitrogen fixation (Schmid et al. 2000, p. 70). This is in line with IPCC, assuming that biological nitrogen fixation supplies 50-60 per cent of the nitrogen in grain legumes (IPCC 1997c, p. 4.89). The total amount of nitrogen is calculated according to the calculation of nitrogen in crop residues. In addition, IULIA takes biological nitrogen fixation on meadows and pastures into account, assuming a nitrogen concentration of 3.5% in the dry matter from which 80% derives from biological nitrogen fixation. For the dry matter production of clover on pastures and meadows statistical data were used (Schmid et al. 2000, p. 70). The following table gives an overview of the calculation of emissions from N-fixing crops.

Table 6-14 Input values for calculation of emissions from N-fixing crops according to IULIA (Schmid et al. 2000, p. 70).

Fixation	**Share of N caused by fixation**	**Share of N in Dry matter**
Leguminous (N-fixing crops)	0.6	crop specific
Clover (Fixation meadows and pastures)	0.8	0.035

- Emissions from **cultivated organic soils** are based on estimations on the area of cultivated organic soils (OA 2011) and the IPCC default emission factor for N_2O emissions from cultivated organic soils (IPCC 1997b).

Emissions from animal production (pasture, range and paddock manure) (4D2)

The calculation of the N excretion per animal category refer to chapter 6.3.2.2 on N_2O Emissions. Calculation of these emissions are based on AGRAMMON (2010). IPCC equation 4.18, IPCC 2000: p. 4.42 is used, but specific N excretion rates and manure system distribution fractions (MS) are used. The relevant input data are based on Flisch et al. (2009) and calculated with the Swiss ammonium model AGRAMMON.

Only emissions of Pasture range and Paddock are to be reported under agricultural soils. Other emissions from animal production are reported under 4B Manure Management.

Indirect emissions (4D3)

Calculation of the indirect emissions is based on IPCC 2000 Tier 1b.

- For calculation of N_2O emissions from **leaching and run-off**, N from fertilizers and animal wastes has to be estimated. The data for the cultivated area is taken from Liechtenstein (OA 2011). Other relevant input data such as the information on leaching and run-off is taken from the Swiss statistics FAL/RAC (2001), Prasuhn and Braun (1994) and Braun et al. (1994). FracLeach is set as 0.2 instead of the IPCC default of 0.3 (Prasuhn and Mohni 2003). This value is extrapolated from long-term monitoring and modelling studies from the canton of Berne. According to Schmid et al. (2000, p. 71), the default value of IPCC leads to an overestimation of the emissions from leaching and run-off. The default value is based on a model which assumes that 30% of nitrogen from synthetic fertilizer and deposition is reaching water bodies. According to Schmid et al. (2000) this amount is not representative for N-excretion of livestock animals in Switzerland and therefore Liechtenstein.
- N_2O emissions from **deposition** are based on NH_3 and NO_X emissions:

  NH_3 Losses to the atmosphere are calculated with the EF for 2002 from the Swiss emission model AGRAMMON (Agrammon 2010) as this is the year which is based on a farm survey (see Table 6-15 below). Activity data are Liechtenstein specific (OA 2011). Specific losses for all livestock categories are assumed. Ammonium volatilization of nitrogen in commercial fertilizers is 15% for urea, 2% for other synthetic fertilizers (Vanderweerden and Jarvis 1997) and between 5 and 18% for recycling fertilizers (sewage sludge and compost).

  For NO_X emissions a constant emission factor of 0.7% of nitrogen excretion from livestock animals and commercial fertilizer-N is assumed (Schmid et al. 2000: p. 66, EEA 2007).

  Thus FracGASF is set constant to the level of Switzerland in 2002 according to FOEN (2011) due to lack of own data in Liechtenstein. Furthermore, 2.0 kg NH_3 -N/ha agricultural soil is produced during decomposition of organic material.

Table 6-15 Overview of the ammonia emission factors. Data source is Agrammon (2010)

Ammonia emission factor		
		%
Cattle		32.5
Mature dairy cattle		33.2
Mature non-dairy cattle		28.5
Young cattle		32.0
	Fattening Calves	38.2
	Pre-Weaned Calves	29.2
	Breeding Cattle 1st Year	31.8
	Breeding Cattle 2nd Year	27.9
	Breeding Cattle 3rd Year	29.4
	Fattening Cattle	41.2
Sheep		19.9
	Fattening Sheep	19.9
	Milk Sheep	21.8
Goats		24.5
	Goat places	24.5
Horses		22.0
	Horses < 3 years	18.4
	Horses > 3 years	22.3
Mules and Asses		22.7
Swine		45.9
	Piglets	38.5
	Fattening Pig over 25 kg	47.0
	Dry Sows	46.3
	Nursing Sows	39.0
	Boars	46.6
Poultry		32.0
	Growers	32.4
	Layers	32.1
	Broilers	27.5
	Turkey	29.6
	Other Poultry (Geese, Ducks, Ostriches, Quails)	28.0

6.5.2.2 Emission factors

The following IPCC default emission factors for calculating N_2O emissions from agricultural soils are used.

Table 6-16 Emission factors for calculating N_2O emissions from agricultural soils (IPCC 1997c, tables 4.18 (direct emissions), 4.22 (pasture, range and paddock) and 4.23 (indirect emissions); IPCC 2000: table 4.17 (organic soils).

Emission source	Emission factor
Direct emissions	
Synthetic fertilizer	0.0125 kg N_2O -N/kg N
Animal excreta nitrogen used as fertilizer	0.0125 kg N_2O -N/kg N
Crop residue	0.0125 kg N_2O -N/kg N
N-fixing crops	0.0125 kg N_2O -N/kg N
Organic soils	8 kg N_2O-N/ha/year
Residues pasture, range and paddock	0.0125 kg N_2O -N/kg N
N-fixing pasture, range and paddock	0.0125 kg N_2O -N/kg N
Indirect emissions	
Leaching and run-off	0.025 kg N_2O -N/kg N
Deposition	0.01 kg N_2O -N/kg N
Animal production	
Pasture, range and paddock	0.02 kg N_2O -N/kg N/a
Other (sewage sludge and compost used for fertilizing)	0.0125 kg N_2O –N/kg N

6.5.2.3 Activity data

Activity data for calculation of direct soil emissions has been provided by

- As Liechtenstein has no data on the amount of mineral fertilizer used, data from Switzerland on the average N input per ha from SBV (2010) is used and extrapolated with the area fertilized in Liechtenstein from the Office of Agriculture (OA 2011) with the following formula:

  N input from mineral fertilizer CH [tN/a] / agricultural area CH [ha] * (agricultural area FL [ha] – area alps FL [ha]) = N-Input FL from mineral fertilizer [tN/a].
- Compost: Assumption that 15% of the total amount of compost in Liechtenstein goes into agriculture. N-content of compost stems from Agrar (2001).
- Nitrogen excretion: FAL/RAC (2001 p. 48/49), Schmid et al. (2000), Walther et al. (1994), Flisch et al. (2009), Agrammon (2010)

Relevant activity data for calculating N_2O emissions from soils is displayed in the following table.

Table 6-17 Activity data for calculating N_2O emissions from agricultural soils. For the sake of completeness, values for mineral (synthetic) fertilizer, sewage sludge and compost are displayed. For calculation of the emissions only the total amount of synthetic fertilizer is used.

Related activity data		**1990-1999**									
		1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
		Value									
Direct emissions											
Fertilizers (t N/yr)	Sum	223	237	233	222	209	207	191	171	172	177
	Mineral fertilizer (t N/yr)	201	204	205	191	181	184	174	153	157	164
	Sewage sludge (t N/yr)	22	32	27	30	28	23	16	18	15	12
	Compost (t N/yr)	0.3	0.2	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.4
Animal manure	Nitrogen input from manure applied to soils (t N/yr)	236	240	232	218	222	220	223	223	220	211
N-fixing crops	N fixation peas, dry beans, soybeans and leguminous vegetables (t N/yr)	143	147	150	153	159	165	162	163	164	165
Crop residue	N from crop residues (t N/yr)	191	198	199	200	202	205	198	197	196	195
Meadows and pasture	Area of meadows and pasture (ha)	4'181	4'202	4'224	4'245	4'267	4'288	4'298	4'307	4'317	4'326
Organic soils	Area of cultivated organic soils (ha)	159	159	159	159	159	159	159	159	159	159
Animal production											
Pasture, range and paddock	N excretion on pasture range and paddock (t N/yr)	102	101	99	93	92	92	96	95	94	91
Indirect emissions											
	N excretion of all animals (t N/yr)	493	498	482	454	460	457	462	462	454	436
	Fertilizer (t N/yr) (before losses)	240	257	251	240	227	223	204	183	184	188
Leaching and run-off	N from fertilizers and animal manure that is lost through leachin and run off (t N/yr)	147	151	147	139	137	136	133	129	128	125
Deposition	Emissions NH3 from fertilizers, animal manure and agricultural soils (tN/yr)	187	193	185	176	178	176	172	172	168	161
	Emissions NOx from fertilizers and animal manure (t N/yr)	5	5	5	5	5	5	5	5	4	4
	Area of agricultural soils (ha)	5'278	5'298	5'318	5'337	5'357	5'377	5'397	5'417	5'436	5'456
	Sum volatized N (NH3 and NOx) from fertilizers, animal manure and agricultural soils (t N/yr)	192	199	190	181	183	181	176	176	172	165

Related activity data		**2000-2009**									
		2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
		Value									
Direct emissions											
Fertilizers (t N/yr)	Sum	171	181	176	170	166	163	160	168	159	151
	Mineral fertilizer (t N/yr)	163	176	172	165	166	163	160	167	159	150
	Sewage sludge (t N/yr)	8	4	4	4	0	0	0	0	0	0
	Compost (t N/yr)	0.4	0.3	0.4	0.4	0.4	0.5	0.4	0.5	0.6	0.4
Animal manure	Nitrogen input from manure applied to soils (t N/yr)	206	217	223	224	223	230	239	243	245	244
N-fixing crops	N fixation peas, dry beans, soybeans and leguminous vegetables (t N/yr)	167	169	171	177	181	181	179	183	178	175
Crop residue	N from crop residues (t N/yr)	194	195	196	200	202	198	198	199	198	196
Meadows and pasture	Area of meadows and pasture (ha)	4'336	4'368	4'400	4'543	4'670	4'570	4'546	4'568	4'523	4'492
Organic soils	Area of cultivated organic soils (ha)	159	159	159	159	159	159	159	159	159	159
Animal production											
Pasture, range and paddock	N excretion on pasture range and paddock (t N/yr)	83	93	93	95	99	103	109	110	111	110
Indirect emissions											
	N excretion of all animals (t N/yr)	424	449	462	465	467	483	503	511	515	513
	Fertilizer (t N/yr) (before losses)	181	190	185	178	173	170	167	175	166	157
Leaching and run-off	N from fertilizers and animal manure that is lost through leachin and run off (t N/yr)	121	128	129	129	128	131	134	137	136	134
Deposition	Emissions NH3 from fertilizers, animal manure and agricultural soils (tN/yr)	159	163	170	171	167	173	178	182	182	181
	Emissions NOx from fertilizers and animal manure (t N/yr)	4	4	5	5	4	5	5	5	5	5
	Area of agricultural soils (ha)	5'476	5'476	5'476	5'476	5'476	5'476	5'476	5'476	5'476	5'476
	Sum volatized N (NH3 and NOx) from fertilizers, animal manure and agricultural soils (t N/yr)	163	167	174	175	172	177	183	186	187	186

Related activity data		**2010**
		Value
Direct emissions		
Fertilizers (t N/yr)	Sum	151
	Mineral fertilizer (t N/yr)	150
	Sewage sludge (t N/yr)	0
	Compost (t N/yr)	0.4
Animal manure	Nitrogen input from manure applied to soils (t N/yr)	236
N-fixing crops	N fixation peas, dry beans, soybeans and leguminous vegetables (t N/yr)	175
Crop residue	N from crop residues (t N/yr)	196
Meadows and pasture	Area of meadows and pasture (ha)	4'492
Organic soils	Area of cultivated organic soils (ha)	159
Animal production		0
Pasture, range and paddock	N excretion on pasture range and paddock (t N/yr)	109
Indirect emissions		0
	N excretion of all animals (t N/yr)	498
	Fertilizer (t N/yr) (before losses)	157
Leaching and run-off	N from fertilizers and animal manure that is lost through leachin and run off (t N/yr)	131
Deposition	Emissions NH3 from fertilizers, animal manure and agricultural soils (tN/yr)	175
	Emissions NOx from fertilizers and animal manure (t N/yr)	5
	Area of agricultural soils (ha)	5'476
	Sum volatized N (NH3 and NOx) from fertilizers, animal manure and agricultural soils (t N/yr)	180

6.5.3 Uncertainties and Time-Series Consistency

For the uncertainty analysis the following input data from the Swiss Agroscope Reckenholz-Tänikon Research Station ART was used (ART 2008):

Table 6-18 Input data for the uncertainty analysis of the source category 4D “Agricultural Soils”. (ART 2008).

Input data for uncertainty analysis 4D	**Lower bound (2.5 Percentile**	**Upper bound (97.5 Percentile)**	**mean uncertainty**
Activity data 4D1 (fertilizer, kg N)	-12.4%	+10.3%	±11.3%
Activity data 4D1 (organic soils, hectares)	-29.4%	+29.4%	±29.4%
Activity data 4D2 (kg N)	-54.2%	+60.5%	±57.3%
Activity data 4D3 (deposition, kg N)	-34.6%	+48.3%	±41.4%
Activity data 4D3 (leaching and run-off, kg N)	-22.2%	+22.0%	±22.1%
Emission factor 4D1 (fertilizer, kg N_2O-N / kg N)	-80%	+80%	±80%
Emission factor 4D1 (organic soils, kg N_2O-N / kg N)	-75%	+87.5%	±81.3%
Emission factor 4D2 (kg N_2O-N / kg N)	-75%	+50%	±62.5%
Emission factor 4D3 (deposition, kg N_2O-N / kg N)	-80%	+100%	±90%
Emission factor 4D3 (leaching and run-off, kg N_2O-N / kg N)	-92%	+380%	±236%

It is assumed that uncertainty estimations from Switzerland are also applicable for Liechtenstein, since Liechtenstein applies the same methodology and emission factors. Also for activity data country specific uncertainty estimations are not available. Therefore, Swiss estimations are used as a first guess.

To apply for the Tier 1 uncertainty analysis, the arithmetic mean of lower and upper bound is used for activity data uncertainty and for emission factor uncertainty. For further results see Section 1.7.

Time series between 1990 and 2010 is consistent.

6.5.4 Source-Specific QA/QC and Verification

In the Agriculture sector special source-specific QA/QC activities have been carried out. A major revision of the background calculation model has been done in cooperation with an external Swiss agriculture expert, based on the Swiss Methodology in FOEN (2011) and with Liechtenstein specific adaptions (OEP 2011b).

Also, as mentioned in sections sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010) has been executed, and changes compared to Submission 2011 had to be retraced to the changes caused by the major revision.

Documentation of the new calculation method adapted from Switzerland assures transparency and traceability of the calculation methods and data sources (OEP 2011b, FOEN 2011). A quality control was done by Acontec and INFRAS by a countercheck of the calculation sheets.

The SE, the NIC and the NIR author report their QC activities in a checklist (see Annex 8).

6.5.5 Source-Specific Recalculations

Liechtenstein's methodology in general has been improved in response to various review questions (e.g. question s Q5, Q8 and Q13, and Para 58 in the FCCC/ARR 2010). With the implementation of these new methodology/calculation sheets, the consistency between N excretion in 4B and 4D is now guaranteed.
Also the amount of synthetic fertilizer has been recalculated for the whole time series due to recalculations in the amount of synthetic fertilizer in Switzerland in the Submission 2011 (FOEN 2011).

6.5.6 Source-Specific Planned Improvements

No further source-specific Improvements are planned.

6.6 Source Category 4E – Burning of savannas

Burning of savannas does not occur (NO) as this is not an agricultural practice in Liechtenstein.

6.7 Source Category 4F – Field Burning of Agricultural Residues

Field burning of agricultural residues is not occurring in Liechtenstein.

7 Land Use, Land-Use Change and Forestry

7.1 Overview

This chapter includes information about the estimation of greenhouse gas emissions and removals from land use, land-use change and forestry (LULUCF). The data acquisition and calculations are based on the Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003). They are completed by country specific methodologies from Switzerland, which were almost fully adopted to Liechtenstein.

The land areas from 1990 to 2003 are represented by geographically explicit land-use data with a resolution of one hectare (following a Tier 3 approach; IPCC 2003). Direct and repeated assessment of land use with full spatial coverage also enables to calculate spatially explicit land-use change matrices. Land-use statistics for Liechtenstein are available for the years 1984, 1996, 2002 and 2008. They are based on the same methodology as the Swiss land-use statistics (SFSO 2006a). In this submission the new 2009 dataset, based on the 2008 Land-use statistics is used for the first time. This 2009 dataset is based on a new coding, leading to minor changes in the time series.

In Liechtenstein, country specific emission factors and carbon stock values for forests and partially for agricultural land and grassland were applied. For other land use categories, IPCC default values or expert estimates from Switzerland are used.

The six main land categories required by IPCC (2003) are: A. Forest Land, B. Cropland, C. Grassland, D. Wetlands, E. Settlements and F. Other Land. These categories were further divided in 18 sub-divisions of land use (Table 7-3). A further spatial stratification reflects the criteria ‘altitude’ (3 zones) and ‘soil type’ (mineral, organic).

Table 7-2 shows the net CO_2 removals of the LULUCF sector. Figure 7-1 and Table 7-1 summarize the CO_2 equivalent emissions and removals in consequence of carbon losses and gains for the years 1990-2010. The total net removals/emissions of CO_2 equivalent vary between -3.42 Gg (2002) and -8.43 Gg (1996) from 1990 to 2010. Three components of the CO_2 balance are shown separately:

- Increase of living biomass on forest land: this is the growth of biomass on forest land remaining forest land; it is the largest sink of carbon.
- Decrease of living biomass on forest land: this is the decrease of carbon in living biomass (by harvest and mortality) on forest land remaining forest land; it is the largest source of carbon.
- Land-use change and soil: this is all the rest including carbon removals/emissions due to land-use changes and use of soils, especially of organic soils.

In all the years, growth of biomass exceeds the harvesting and mortality rate. Compared to these biomass changes in forests, the net CO_2 equivalent emissions arising from all land-use changes and from the soils are relatively small (see Figure 7-1).

Table 7-1 Liechtenstein's CO_2 equivalent emissions/removals [Gg] of the source category 5 LULUCF 1990-2010. Positive values refer to emissions; negative values refer to removals from the atmosphere.

LULUCF	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	Gg CO2									
Increase of living biomass in forest	-68.7	-68.8	-68.9	-69.0	-69.1	-69.2	-69.2	-70.9	-70.9	-70.9
Decrease of living biomass in forest	50.3	50.4	50.5	50.5	50.6	50.6	50.7	51.7	51.8	51.8
Land-use change and soil	10.2	10.2	10.2	10.1	10.1	10.1	10.1	15.7	15.7	15.7
Sector 5 LULUCF (total)	**-8.22**	**-8.25**	**-8.29**	**-8.32**	**-8.36**	**-8.39**	**-8.43**	**-3.46**	**-3.45**	**-3.44**

LULUCF	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	Gg CO2									
Increase of living biomass in forest	-70.9	-70.9	-70.9	-70.0	-70.1	-70.1	-70.2	-70.2	-70.3	-70.3
Decrease of living biomass in forest	51.8	51.8	51.8	51.9	51.9	52.0	52.0	52.1	52.1	52.1
Land-use change and soil	15.7	15.7	15.7	12.1	12.1	12.1	12.1	12.0	12.0	12.3
Sector 5 LULUCF (total)	**-3.43**	**-3.42**	**-3.42**	**-6.02**	**-6.04**	**-6.06**	**-6.08**	**-6.10**	**-6.12**	**-6.02**

LULUCF	**2010**	**Mean**
Increase of living biomass in forest	-70.0	-70.0
Decrease of living biomass in forest	51.5	51.5
Land-use change and soil	12.5	12.5
Sector 5 LULUCF (total)	**-6.06**	**-6.06**

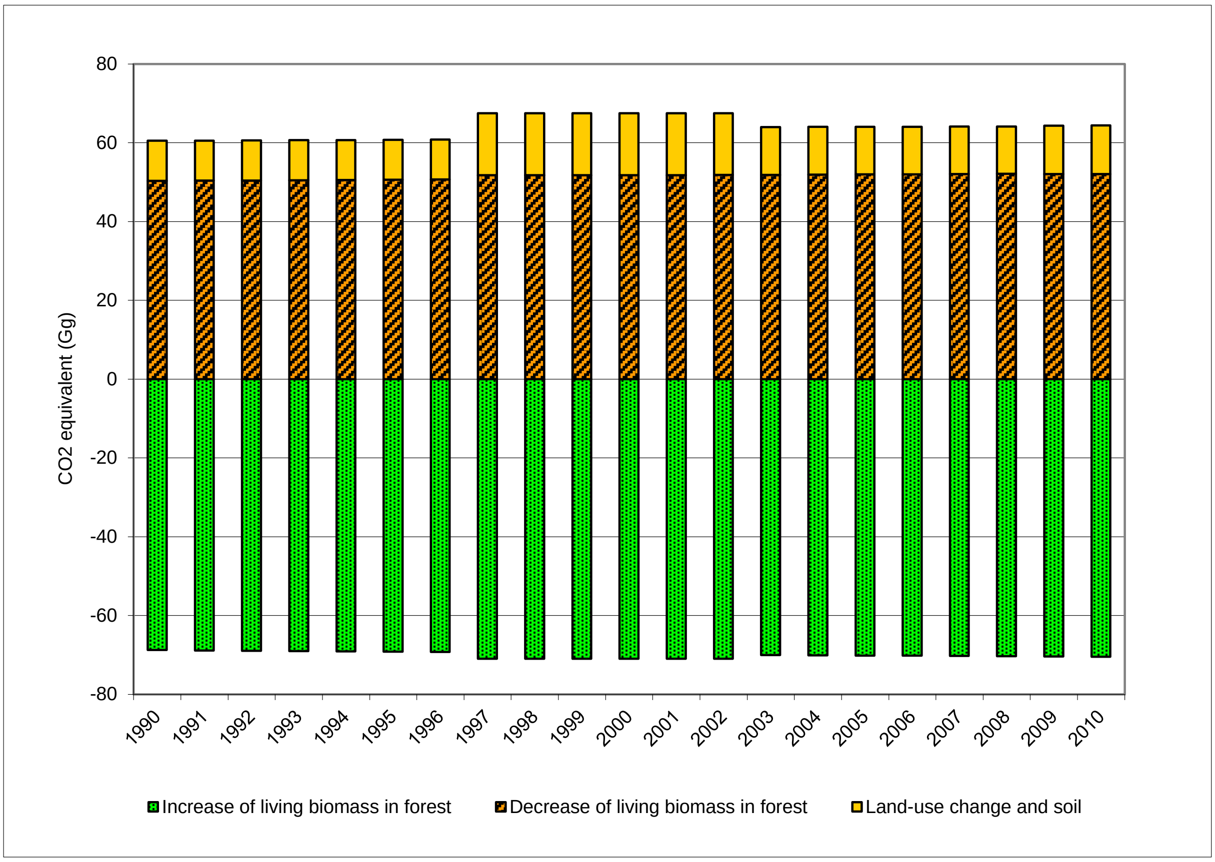


Figure 7-1 The CO_2 removals due to the increase (growth) of living biomass on forest land, the CO_2 emissions due to the decrease (harvest and mortality) of living biomass on forest land and the net CO_2 equivalent emissions due to land-use changes and from use of soils, 1990–2010.

Increase and decrease of living biomass in forests are the dominant categories when looking at the CO_2 emissions and removals (refer to Table 7-1 and Figure 7-1). Emissions and removals from forest land are quite stable over time. The dominant category when looking at the changes in net CO_2 removals are grassland and settlements (refer to Table 7-2). It can be observed that land-use conversions from and to grassland differ significantly between the three time periods 1990 to 1996, 1997 to 2002 and 2003 to 2010. In the period 1997 to 2002 a significant higher conversion from forest land to grassland lead to a reduction of net CO_2 removals.

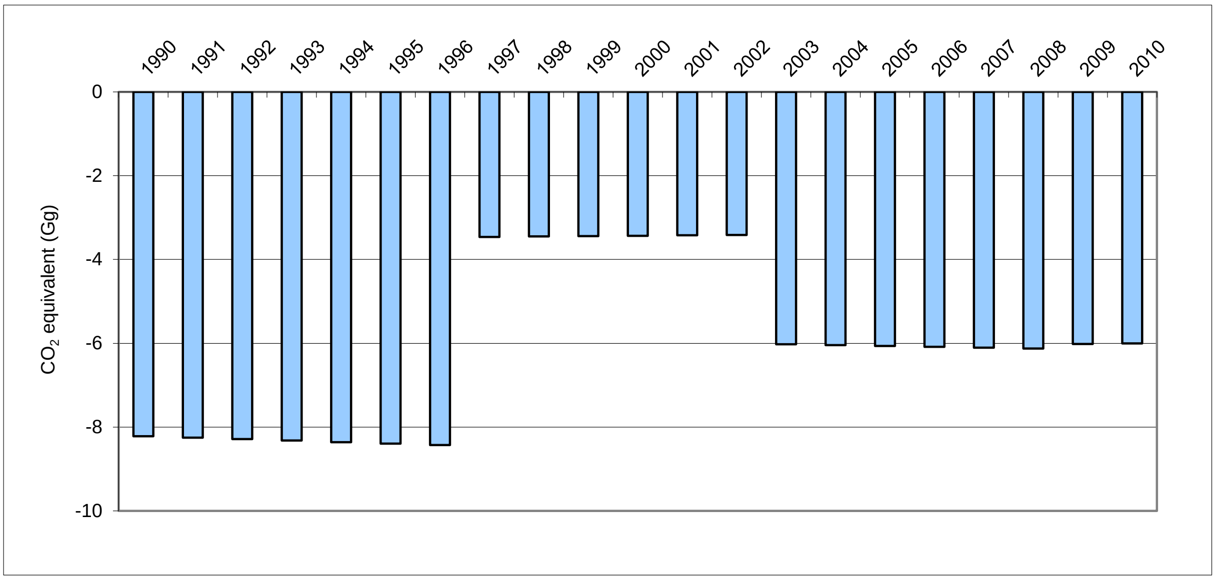


Figure 7-2 Liechtenstein's CO_2 emissions/removals of source category 5 LULUCF 1990–2010 in Gg CO_2 equivalent. Negative values refer to removals.

Table 7-2 Net CO_2 removals and emissions per land-use category in Gg CO_2 eq., 1990-2010.

Net CO_2 emissions/removals	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Total Land-Use Categories	**-8.22**	**-8.25**	**-8.29**	**-8.32**	**-8.36**	**-8.39**	**-8.43**	**-3.46**	**-3.45**	**-3.44**
A. Forest Land	**-18.74**	**-18.76**	**-18.78**	**-18.79**	**-18.81**	**-18.83**	**-18.85**	**-19.68**	**-19.67**	**-19.65**
1. Forest Land remaining Forest Land	-18.64	-18.65	-18.67	-18.69	-18.71	-18.72	-18.74	-19.60	-19.58	-19.57
2. Land converted to Forest Land	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.08	-0.08	-0.08
B. Cropland	**4.44**	**4.43**	**4.43**	**4.42**	**4.42**	**4.41**	**4.41**	**4.56**	**4.58**	**4.61**
1. Cropland remaining Cropland	4.33	4.32	4.32	4.31	4.31	4.30	4.29	4.32	4.34	4.36
2. Land converted to Cropland	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.24	0.24	0.24
C. Grassland	**2.14**	**2.13**	**2.12**	**2.10**	**2.09**	**2.08**	**2.07**	**5.33**	**5.31**	**5.28**
1. Grassland remaining Grassland	2.13	2.12	2.11	2.10	2.08	2.07	2.06	2.04	2.01	1.98
2. Land converted to Grassland	0.01	0.01	0.01	0.01	0.01	0.01	0.01	3.30	3.30	3.30
D. Wetlands	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.16**	**0.36**	**0.36**	**0.36**
1. Wetlands remaining Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to Wetlands	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.36	0.36	0.36
E. Settlements	**3.35**	**3.35**	**3.35**	**3.35**	**3.35**	**3.35**	**3.35**	**4.01**	**4.01**	**4.01**
1. Settlements remaining Settlements	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06
2. Land converted to Settlements	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.95	3.95	3.95
F. Other Land	**0.44**	**0.44**	**0.44**	**0.44**	**0.44**	**0.44**	**0.44**	**1.95**	**1.95**	**1.95**
1. Other Land remaining Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Land converted to Other Land	0.44	0.44	0.44	0.44	0.44	0.44	0.44	1.95	1.95	1.95

Net CO_2- emissions/removals	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total Land-Use Categories	**-3.43**	**-3.42**	**-3.42**	**-6.02**	**-6.04**	**-6.06**	**-6.08**	**-6.10**	**-6.12**	**-6.02**
A. Forest Land	**-19.64**	**-19.62**	**-19.61**	**-18.34**	**-18.35**	**-18.36**	**-18.37**	**-18.37**	**-18.38**	**-18.54**
1. Forest Land remaining Forest Land	-19.55	-19.54	-19.52	-18.28	-18.28	-18.29	-18.30	-18.30	-18.31	-18.47
2. Land converted to Forest Land	-0.08	-0.08	-0.08	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07
B. Cropland	**4.63**	**4.65**	**4.68**	**4.48**	**4.48**	**4.49**	**4.49**	**4.49**	**4.50**	**4.50**
1. Cropland remaining Cropland	4.39	4.41	4.43	4.44	4.44	4.44	4.45	4.45	4.46	4.46
2. Land converted to Cropland	0.24	0.24	0.24	0.04	0.04	0.04	0.04	0.04	0.04	0.04
C. Grassland	**5.25**	**5.22**	**5.19**	**3.44**	**3.42**	**3.40**	**3.39**	**3.37**	**3.35**	**3.41**
1. Grassland remaining Grassland	1.95	1.92	1.89	1.77	1.75	1.74	1.72	1.70	1.68	1.72
2. Land converted to Grassland	3.30	3.30	3.30	1.67	1.67	1.67	1.67	1.67	1.67	1.69
D. Wetlands	**0.36**	**0.36**	**0.36**	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**	**0.13**
1. Wetlands remaining Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Land converted to Wetlands	0.36	0.36	0.36	0.17	0.17	0.17	0.17	0.17	0.17	0.13
E. Settlements	**4.01**	**4.01**	**4.01**	**3.28**	**3.28**	**3.28**	**3.28**	**3.28**	**3.28**	**3.33**
1. Settlements remaining Settlements	0.06	0.06	0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.04
2. Land converted to Settlements	3.95	3.95	3.95	3.24	3.24	3.24	3.24	3.24	3.24	3.29
F. Other Land	**1.95**	**1.95**	**1.95**	**0.95**	**0.95**	**0.95**	**0.95**	**0.95**	**0.95**	**1.15**
1. Other Land remaining Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Land converted to Other Land	1.95	1.95	1.95	0.95	0.95	0.95	0.95	0.95	0.95	1.15

Net CO_2- emissions/removals	**2010**
Total Land-Use Categories	**-6.00**
A. Forest Land	**-18.55**
1. Forest Land remaining Forest Land	-18.48
2. Land converted to Forest Land	-0.07
B. Cropland	**4.54**
1. Cropland remaining Cropland	4.46
2. Land converted to Cropland	0.08
C. Grassland	**3.39**
1. Grassland remaining Grassland	1.70
2. Land converted to Grassland	1.69
D. Wetlands	**0.13**
1. Wetlands remaining Wetlands	NO
2. Land converted to Wetlands	0.13
E. Settlements	**3.33**
1. Settlements remaining Settlements	0.04
2. Land converted to Settlements	3.29
F. Other Land	**1.15**
1. Other Land remaining Other Land	0.00
2. Land converted to Other Land	1.15

The next chapter (7.2) gives an overview of the methodical approach including the calculation of the activity data (land-use data) and carbon emissions. The subsequent chapters (7.3- 7.8) describe the details of the CO_2 equivalent removal/emission calculations for each main land-use category.

Non CO_2-emissions are very small or even zero (Total LULUCF 0.000015 Gg N_2O in 2010). They arise from soil disturbances associated with land-conversion to cropland (CRF Table 5 III). The calculation method is based on IPCC default procedures (IPCC 2003, chapter 3) and summarized in chapter 7.4.2.

7.2 Methodical Approach and Activity Data

7.2.1 General Approach for Calculating Carbon Emissions/Removals

The selected procedure for calculating carbon emissions and removals in the LULUCF sector is done as for Switzerland (FOEN 2006a). It corresponds to a Tier 2 approach as described in IPCC (2003; chapter 3) and can be summarised as follows:

- Land use categories and sub-divisions with respect to available land-use data (see Table 7-3) were defined. For these carbon emissions and removals estimations so-called combination categories (CC) were defined on the basis of the land-use and land-cover categories of the Swiss land-use statistics (FOEN 2006; SFSO 2006a).
- Criteria for the spatial stratification of the land-use categories (altitude and soil type) were taken from Switzerland. Based on these criteria data for the spatial stratification of the land-use categories were collected in Liechtenstein.
- For carbon stocks and carbon stock changes for each spatial stratum of the land-use categories Swiss data based on measurements and estimations were taken.
- The land use and the land-use change matrix were calculated in each spatial stratum.
- Carbon stock changes in living biomass (deltaC_l), in dead organic matter (deltaC_d) and in soil (deltaC_s) were calculated for all cells of the land-use change matrix.
- Finally, the results were aggregated by summarising the carbon stock changes over land-use categories and strata according to the level of disaggregation displayed in the CRF tables.

The procedure of calculating emissions and removals in LULUCF and the different institutions involved are displayed in Figure 7-3.

The distinction between managed and unmanaged land is done as follows:

- Forest land is by definition managed land as all forests in Liechtenstein are subject to forest management.
- Land categories where nothing can be cultivated on it, are classified as unmanaged. This holds for stony grassland, unproductive grassland, surface waters and unproductive wetland and other land (rocks, sand, glaciers).

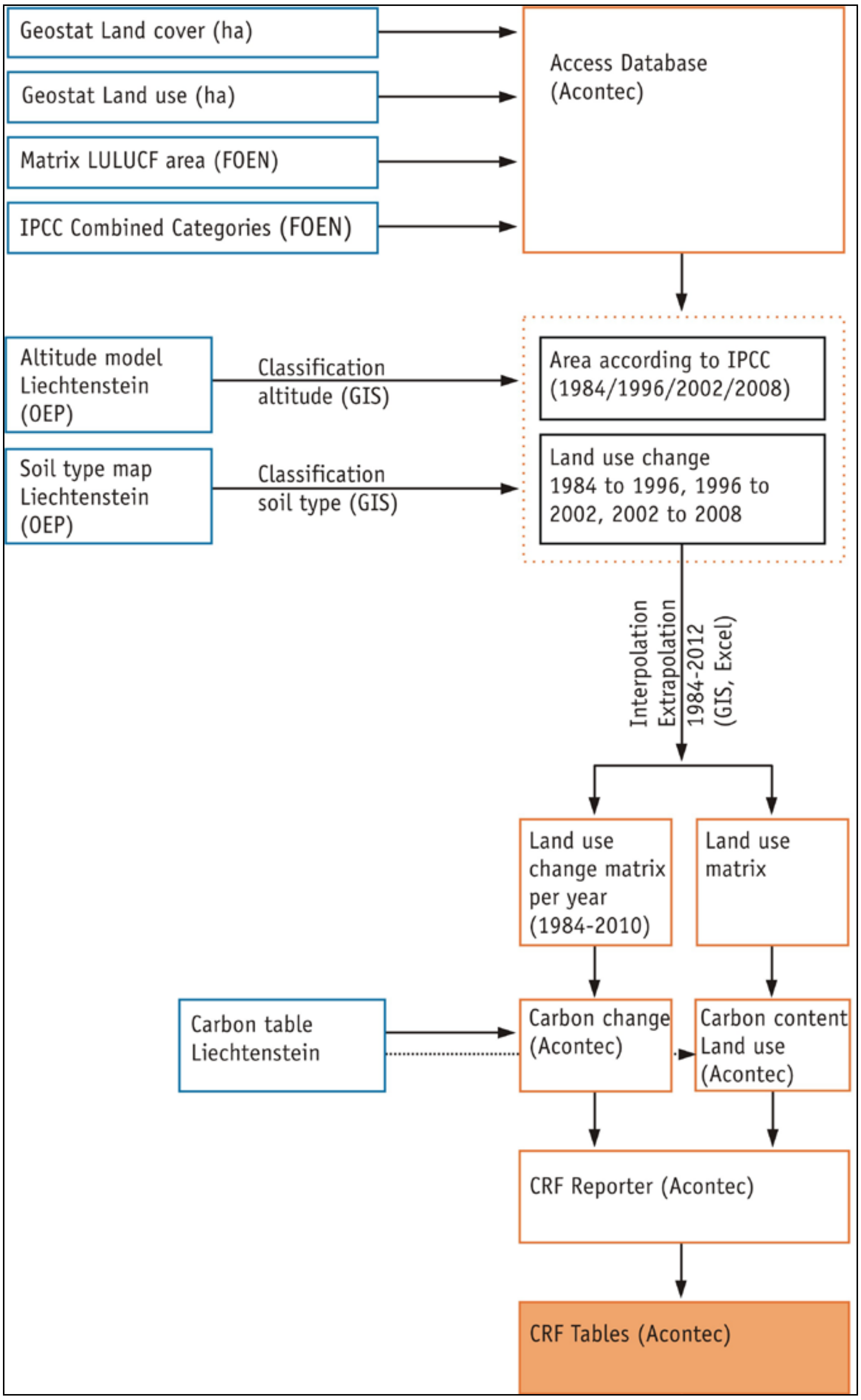


Figure 7-3 Procedure of calculating emissions and removals from LULUCF in Liechtenstein.

The following paragraph gives some further explanations about the Swiss calculation of carbon stock changes:

Swiss methodology (excerpt from NIR CH, chpt. 7.2.1, FOEN 2007):

Table 7-3 Land-use categories used in this report (so-called combination categories CC): 6 main land-use categories and the 18 sub-divisions. Additionally, descriptive remarks, abbreviations used in the CRF tables, and CC codes are given. For a detailed definition of the CC categories see FOEN (2006) and SFSO (2006a).

CC Main category	**CC Sub-division**	**Remarks**	**Managed or unmanaged**	***CC code***
A. Forest Land	Afforestations	areas converted to forest by active measures, e.g. planting[14]	managed	*11*
	Managed Forest	dense and open forest meeting the criteria of forest land	managed	*12*
	Unproductive Forest	brush forest and inaccessible forest meeting the criteria of forest land	managed	*13*
B. Cropland		arable and tillage land (annual crops and leys in arable rotations)	managed	*21*
C. Grassland	Permanent Grassland	meadows, pastures (low-land and alpine)	managed	*31*
	Shrub Vegetation	agricultural and unproductive areas predominantly covered by shrubs	managed	*32*
	Vineyards, Low-Stem Orchards, Tree Nurseries	perennial agricultural plants with woody biomass (no trees)	managed	*33*
	Copse	agricultural and unproductive areas covered by perennial woody biomass including trees	managed	*34*
	Orchards	permanent grassland with fruit trees	managed	*35*
	Stony Grassland	grass, herbs and shrubs on stony surfaces	unmanaged	*36*
	Unproductive Grassland	unmanaged grass vegetation	unmanaged	*37*
D. Wetlands	Surface Waters	lakes and rivers	unmanaged	*41*
	Unproductive Wetland	reed, unmanaged wetland	unmanaged	*42*
E. Settlements	Buildings and Constructions	areas without vegetation such as houses, roads, construction sites, dumps	managed	*51*
	Herbaceous Biomass in Settlements	areas with low vegetation, e.g. lawns	managed	*52*
	Shrubs in Settlements	areas with perennial woody biomass (no trees)	managed	*53*
	Trees in Settlements	areas with perennial woody biomass including trees	managed	*54*
F. Other Land		areas without soil and vegetation: rocks, sand, screes, glaciers	unmanaged	*61*

[14] Reforestation does not occur in Liechtenstein. For more than 100 years, the area of forest has not decreased anymore. Any reforestation would have required a deforestation within the last 50 years, but deforestation is prohibited by law (OEP 2007b).

For calculating carbon stock changes, the following input parameters (mean values per hectare) must be quantified for all land-use categories (CC) and spatial strata (i):

$stockC_{l,i,CC}$: *carbon stock in living biomass*
$stockC_{d,i,CC}$: *carbon stock in dead organic matter*
$stockC_{s,i,CC}$: *carbon stock in soil*
$increaseC_{l,i,CC}$: *annual increase (growth) of carbon in living biomass*
$decreaseC_{l,i,CC}$: *annual decrease (harvesting) of carbon in living biomass*
$changeC_{d,i,CC}$: *annual net carbon stock change in dead organic matter*
$changeC_{s,i,CC}$: *annual net carbon stock change in soil*

On this basis, the carbon stock changes in living biomass ($deltaC_l$), in dead organic matter ($deltaC_d$) and in soil ($deltaC_s$) are calculated for all cells of the land-use change matrix. Each cell is characterized by a land-use category before the conversion (b), a land-use category after the conversion (a) and the area of converted land within the spatial stratum (i). Equations 7.2.1.-7.2.3 show the general approach of calculating C-removals/emissions taking into account the net carbon stock changes in living biomass, dead organic matter and soils as well as the stock changes due to conversion of land use (difference of the stocks before and after the conversion):

$$deltaC_{l,i,ba} = [\, increaseC_{l,i,a} - decreaseC_{l,i,a} + W_l * (stockC_{l,i,a} - stockC_{l,i,b}) \,] * A_{i,ba} \quad (7.2.1)$$

$$deltaC_{d,i,ba} = [\, changeC_{d,i,a} + W_d * (stockC_{d,i,a} - stockC_{d,i,b}) \,] * A_{i,ba} \quad (7.2.2)$$

$$deltaC_{s,i,ba} = [\, changeC_{s,i,a} + W_s * (stockC_{s,i,a} - stockC_{s,i,b}) \,] * A_{i,ba} \quad (7.2.3)$$

where:

a: land-use category after conversion (CC = a)
b: land-use category before conversion (CC = b)
ba: land use conversion from b to a
$A_{i,ba}$: *area of land converted from b to a in the spatial stratum i (activity data from the land-use change matrix)*
W_l, W_d, W_s: *weighting factors for living biomass, dead organic matter and soil, respectively.*

The following values for W were chosen:

$W_l = W_d = W_s = 0$ *if land use after the conversion is 'Forest Land' (a = {11,12,13}) or if a and b are unmanaged categories {36,37,41,42,61}*

$W_s = 0.5$ *if a or b is 'Buildings and Constructions' (a = 51 or b = 51)*

$W_l = W_d = W_s = 1$ *otherwise.*

The difference of the stocks before and after the conversion are weighted with a factor (W_l, W_d, W_s) accounting for the effectiveness of the land-use change in some special cases. For example, the succession from grassland to forest land is quite frequent in mountainous regions [in Switzerland]. Immediately after the conversion young forests have lower carbon stocks than the mean carbon stock values determined for 'managed forest'. Therefore, the weighting factors for the conversion 'to forest land' was set to zero in order to avoid an overestimation of C-sinks. In the case of land-use changes involving 'buildings and constructions' it is assumed that only 50% of the soil carbon is emitted as the humus layer is re-used on construction sites.

For all land-use categories applies: If a equals b, there is no change in land use and the difference in carbon stocks becomes zero.

For calculating annual carbon stock changes in soils due to land-use conversion, IPCC (2003) suggested a default delay time (inventory period) of 20 years. In this study, the inventory period of land-use changes is predetermined by the inter-survey period of the Swiss land-use statistics and averages approximately 12 years.

In the CRF tables 5.A to 5.F, land-use categories (CC) and associated spatial strata are partially shown at an aggregated level for optimal documentation and overview. The values of deltaC are accordingly summarised. Positive values of $deltaC_{l,i,ba}$ *are inserted in the column "Increase" and negative values in column "Decrease", respectively (besides* $increaseC_{l,i,CC}$ *and* $decreaseC_{l,i,CC}$ *if land-use does not change).*

The weighting factors W equal zero in case of changes between unmanaged categories corresponds a recommendation of the Expert Review Team. After kept as a planned improvement, it is now implemented in the LULUCF modelling scheme.

7.2.2 General Approach for Compiling Land-use Data

7.2.2.1 Land-Use Statistics (AREA)

Land-use data from Liechtenstein are collected according to the same method as in Switzerland. Every hectare of the territory was assigned to one of 46 land-use categories and to one of 27 land-cover categories by means of stereographic interpretation of aerial photos (EDI/BFS 2009).

For the reconstruction of the land use conditions in Liechtenstein for the period 1990-2010 four data sets are used:

- Land-Use Statistics 1984
- Land-Use Statistics 1996
- Land-Use Statistics 2002
- Land-Use Statistics 2008

Land-use statistics from the years 1984 and 1996 were originally evaluated according to a set of different land-use categories. For this purposes they were being re-evaluated according to the newly designed land-use and land-cover categories (SFSO 2006a). For the interpretation of the 2002 data the new land-use and land-cover categories were used directly.

For this submission the latest Land-Use Statistics of 2008 are used for the second time (EDI/BFS 2009). A minor mistake in the area data of the year 2009 from the first use in Submission 2011 has been corrected in this submission.

7.2.2.2 Combination Categories (CC) as derived from Land-Use Statistics

The 46 land-use categories and 27 land-cover categories of the land-use statistics were aggregated to 18 combination categories (CC, FOEN 2006b) implementing the main categories proposed by IPCC as well as by Swiss country specific sub-divisions (see Table 7-3). The sub-divisions were defined with respect to optimal distinction of biomass densities, carbon turnover, and soil carbon contents.

The first digit of the CC-code represents the main category, whereas the second digit stands for the respective sub-division.

Table 7-4 Relation between the different land-use and land-cover categories and the combination categories (CC). FOEN 2006b (revised)

Land Use according to AREA – **18 Kyoto Combination Categories**

Settlements:

Land Cover according to AREA	Gebäudeareal								Verkehrsflächen					Besondere Siedlungsflächen							Erholungs- und Grünanlagen					
	101 Industrie- und Gewerbeareal > 1 ha	102 Industrie- und Gewerbeareal < 1 ha	103 Ein- und Zweifamilienhausareal	104 Reihen- und Terrassenhausareal	105 Mehrfamilienhausareal	106 Öffentliches Gebäudeareal	107 Landwirtschaftliches Gebäudeareal	108 Nicht spezifiziertes Gebäudeareal	121 Autobahnareal	122 Strassenareal	123 Parkplatzareal	124 Bahnareal	125 Flugplatzareal	141 Energieversorgungsanlagen	142 Abwasserreinigungsanlagen	143 Übrige Ver- und Entsorgungsanlagen	144 Deponien	145 Abbau	146 Baustellen	147 Bau- und Siedlungsbrachen	161 Öffentliche Parkanlagen	162 Sportanlagen	163 Golfplätze	164 Campingplätze	165 Schrebergärten	166 Friedhöfe
10 Artificial surfaces																										
11 Befestigte Flächen	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
12 Gebäude	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
13 Treibhäuser	52	52	52	52	52	52	52	52			52	52	52						52	52	52	52	52	52	52	52
14 Beetstrukturen	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52			52	52	52	52	52	52	52	52
15 Rasen	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52			52	52	52	52	52	52	52	52
16 Bäume auf künstlich angelegten Flächen	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54			54	54	54	54	54	54	54	54
17 Gemischte Kleinstrukturen	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52			52	52	52	52	52	52	52	52
20 Herbaceous vegetation																										
21 Gras-, Krautvegetation	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
30 Shrub vegetation																										
31 Gebüsch	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53
32 Verbuschte Flächen	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53
33 Niederstammobst	53	53	53	53	53	53	53	53	53	53	53	53								53	53				53	53
34 Reben	53	53	53	53	53	53	53	53	53	53	53	53								53	53				53	53
35 Gärtnerische Dauerkulturen	52	52	52	52	52	52	52	52	52	52	52	52								52	52				52	52
40 Trees																										
41 Geschlossene Baumbestände	54	54	54	54	54	54	54	54	54		54									54	54	54		54	54	54
42 Waldecken	54	54	54	54	54	54	54	54	54		54			54	54	54				54	54	54	54	54	54	54
43 Waldstreifen	54	54	54	54	54	54	54	54	54		54			54	54	54				54	54	54		54	54	54
44 Aufgelöste Baumbestände	54	54	54	54	54	54	54	54	54		54			54	54	54				54	54	54		54	54	54
45 Gebüschwaldbestände																					53			53		
46 Lineare Baumbestände	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54
47 Baumgruppen	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54
50 Surfaces without vegetation																										
51 Anstehender Fels	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
52 Lockergestein	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
53 Versteinte Flächen	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
60 Water and wetlands																										
61 Wasser	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41
62 Gletscher, Firn																										
63 Nassstandorte	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42
64 Schilfbestände	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42

Agricultural land, Forest land, Unproductive:

Land Cover according to AREA	Obstbau, Rebbau, Gartenbau			Acker- und Futterbau			Alpwirtschaft			Wald (ohne landwirtschaftliche Nutzung)				Seen und Flüsse			Unproduktives Land			
	201 Obstbau	202 Rebbau	203 Gartenbau	221 Ackerland i.w.S.	222 Naturwiesen i.w.S.	223 Heimweiden i.w.S.	241 Alpwiesen i.w.S.	242 Alp- und Juraweiden i.w.S.	243 Schafalpen i.w.S.	301 Waldbestände	302 Aufforstungen	303 Holzschläge	304 Waldschadenflächen	401 Seen	402 Flüsse, Bäche	403 Hochwasserverbauungen	421 Keine Nutzung	422 Lawinen- und Steinschlagverbauungen	423 Alpine Sportinfrastruktur	424 Landschaftseingriffe
10 Artificial surfaces																				
11 Befestigte Flächen		51	51											51	51	51		51	51	51
12 Gebäude																				
13 Treibhäuser			21																	
14 Beetstrukturen		21	21	21	21		21			12										
15 Rasen		31	31																	
16 Bäume auf künstlich angelegten Flächen																				
17 Gemischte Kleinstrukturen		21	21																	
20 Herbaceous vegetation																				
21 Gras-, Krautvegetation	31	31	31	21	31	31	31	31	31		11	12	12	37	37	37	37	37	37	31
30 Shrub vegetation																				
31 Gebüsch		32	32								11	12	12	32	32	32	32	32	32	32
32 Verbuschte Flächen		32	32		32	32	32	32			11	12	12	32	32	32	32	32	32	32
33 Niederstammobst	33		33																	
34 Reben		33	33																	
35 Gärtnerische Dauerkulturen			33							12										
40 Trees																				
41 Geschlossene Baumbestände	35									12	11					12		12		
42 Waldecken	35									12	11	12	12			12		12		
43 Waldstreifen	35									12	11					12		12		
44 Aufgelöste Baumbestände	35				12	12	12	12	13	12	11	12	12			12		12	12	12
45 Gebüschwaldbestände										13						13		13		
46 Lineare Baumbestände	34	34	34	34	34	34	34	34	34		11	12	12	34	34	34	34	34	34	34
47 Baumgruppen	34	34	34	34	34	34	34	13	34		11	12	12	34	34	34	34	34	34	34
50 Surfaces without vegetation																				
51 Anstehender Fels												13	13	61	61	61	61	61	61	61
52 Lockergestein		61	61									12	12	61	61	61	61	61	61	61
53 Versteinte Flächen		36	36			36	36	36			11	13	13	36	36	36	36	36	36	36
60 Water and wetlands																				
61 Wasser														41	41	41				41
62 Gletscher, Firn																	61			
63 Nassstandorte					42	42	42	42	42			12	13	42	42	42	42	42	42	42
64 Schilfbestände				21	42	42	42	42	42					42	42	42	42			

Kyoto Combination Categories

- 11 Afforestations
- 12 Managed forest
- 13 Unproductive forest
- 21 Cropland
- 31 Permanent grassland
- 32 Shrub vegetation
- 33 Vineyards, Low-stem Orchards, Tree nurseries
- 34 Copse
- 35 Orchards
- 36 Stony grassland
- 37 Unproductive grassland
- 41 Surface waters
- 42 Unproductive wetland
- 51 Buildings and construction
- 52 Herbaceous biomass in settlements
- 53 Shrubs in settlements
- 54 Trees in settlements
- 61 Other land

7.2.2.3 Interpolation and extrapolation of the status for each year

The exact dates of aerial photo shootings are known for each hectare (in Liechtenstein data available for the years 1984, 1996, 2002 and 2008). However, the exact year of the land-use change on a specific hectare is unknown. The actual change can have taken place in any year between the two land-use surveys. It is assumed that the probability of a land-use change from 1984 and 1996, 1996 to 2002 and from 2002 to the 2008 survey is uniformly distributed over the respective interim period between two surveys. Therefore, the land-use change of each hectare has to be equally distributed over its specific interim period (e.g. when a specific area increased by three hectares between 1996 and 2002, it was assumed that the annual increase was 0.5 hectares).

Thus, the land-use status for the years between two data collection dates can be calculated by linear interpolation. Dates of aerial photo and the land-use categories of 1984 and 1996 for every hectare are used for these calculations. The status after 2008 is estimated by linear extrapolation, assuming that the average trend observed between 1984 and 2008 goes on.

Example (Figure 7-4): A certain area has been assigned to the land-use category “Cropland” (CC 21) in 1984. A partial land-use change to “Shrubs in Settlements” (CC 53) has been discovered in 1996. And another partial change to “Buildings and construction” (CC 51) was discovered in 2002.

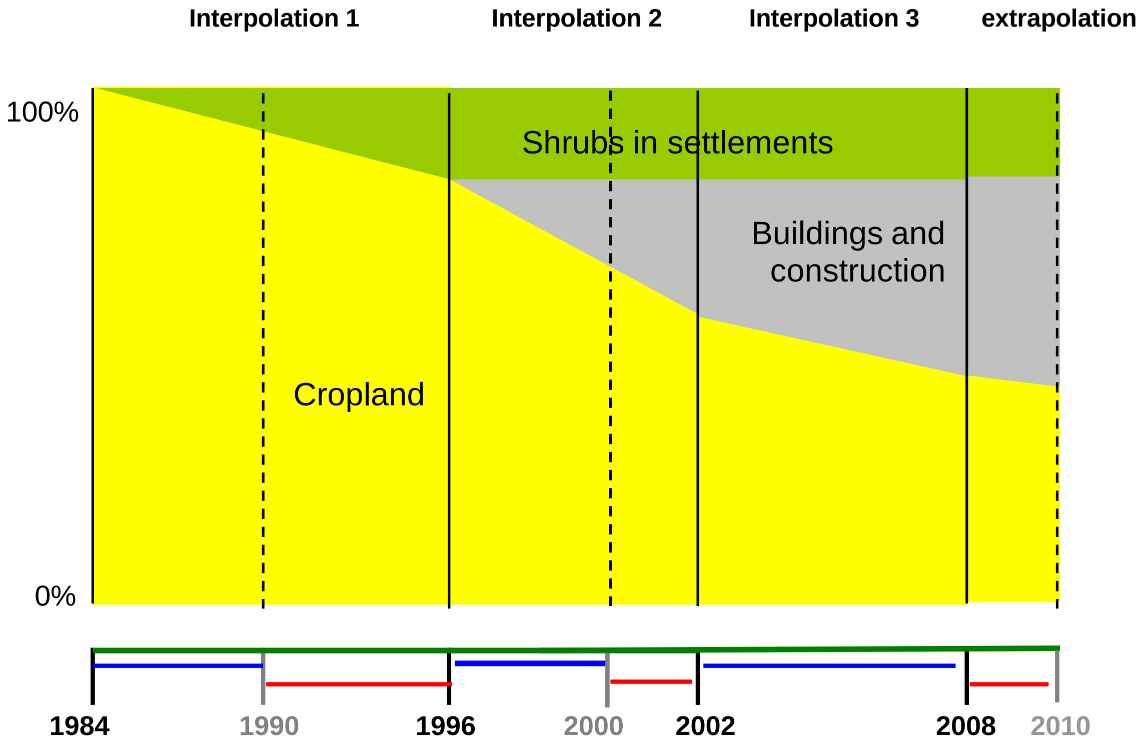


Figure 7-4 Hypothetical linear development of land-use changes between the four different Land Use Statistics (1984, 96, 02, 08) with the example of a hectare changing from “cropland” to “shrubs in settlements” and then twice from "shrubs in settlements" to “buildings and constructions". The dotted lines show how the share of the different Land Use Categories is determined in years between Land Use Statistics.

The ‘status 1990’ is determined by calculating the fractions of the two land-use categories for the year 1990. A linear development from “cropland” to “shrubs in settlements” during the whole interim period is assumed. The same procedure can be applied for two survey dates between 1996 and 2002 (see year 2002 Figure 7-4 as example). Extrapolation after 2008 is done by taking the average trend of the whole time period 1984 to 2008. The ‘status’ for each individual year in the period 1990-2008 for the whole territory of Liechtenstein results from the summation of the fractions of all hectares per combination category CC (considering the spatial strata where appropriate; see Table 7-6).

7.2.3 Spatial Stratification

In order to quantify carbon stocks and increases/decreases, a further spatial stratification of the territory turned out to be useful. For forests and grassland three different altitudinal belts were differentiated. The whole territory of Liechtenstein is considered to be part of the pre-alpine region (Thürig et al. 2004).

Altitude data were available on a hectare-grid from the Office of Environmental Protection (OEP 2006d) and classified in belts ≤ 600 m a.s.l. (metres above sea level), 601-1200 m a.s.l., and >1200 m a.s.l. (Figure 7-5).

For cropland and grassland, two soil types (organic and mineral soils) were additionally differentiated.

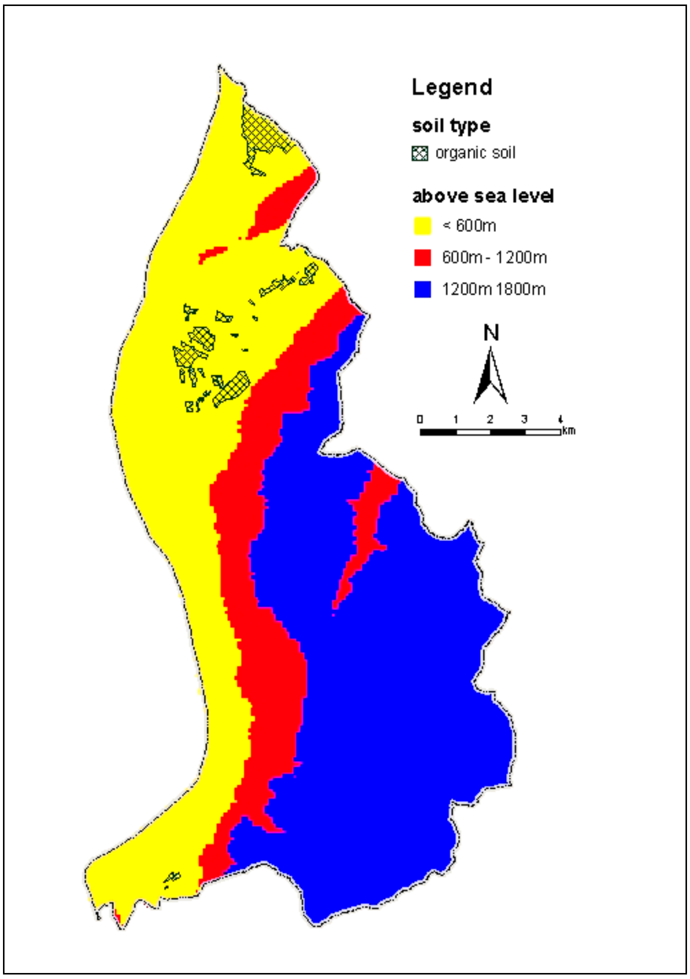


Figure 7-5 Map of Liechtenstein showing the altitude classes and soil types. Reference: OEP 2006d.

7.2.4 The Land-use Tables and Change Matrices (activity data)

Table 7-5 shows the overall trends of land-use changes between 1990 and 2010 for the source and sink categories according to the CRF.

Table 7-5 Statistics of land use for the whole period 1990-2010 (in ha) and change (absolute and relative) between 1990 and 2010. The table displays the data for the land-use categories remaining the same land-use category (excluding land converted to a specific category).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Forest land	6036	6048	6061	6074	6087	6100	6113	6112	6111	6110	6109	6108	6107
Cropland	1952	1948	1943	1938	1933	1928	1923	1916	1909	1902	1895	1888	1881
Grassland	5312	5287	5262	5237	5212	5187	5162	5149	5136	5123	5111	5098	5085
Wetlands	359	356	353	350	347	344	341	348	354	361	367	374	380
Settlements	1367	1384	1401	1418	1436	1453	1470	1489	1507	1526	1544	1563	1581
Other Land	1025	1028	1031	1033	1036	1038	1041	1037	1033	1028	1024	1020	1016
Sum	16050	16050	16050	16050	16050	16050	16050	16050	16050	16050	16050	16050	16050

	2003	2004	2005	2006	2007	2008	2009	2010	Change 1990-2010 (ha)	Change 1990-2010 (%)
Forest land	6108	6116	6124	6132	6139	6131	6137	6143	107.1	1.8%
Cropland	1895	1891	1886	1882	1877	1788	1779	1770	-182.8	-9.4%
Grassland	5041	5019	4997	4975	4953	5056	5042	5028	-283.9	-5.3%
Wetlands	378	378	378	378	379	363	363	364	5.0	1.4%
Settlements	1603	1621	1639	1657	1674	1691	1709	1727	360.6	26.4%
Other Land	1025	1026	1026	1027	1028	1021	1021	1021	-5.0	-0.5%
Sum	16050	16050	16050	16050	16050	16050	16050	16051	0.9	0.0%

The most significant land-use changes in absolute terms since 1990 can be observed in the categories cropland (decrease by 9.4%), grassland (-5.3%) and settlements (increase by 26.4 %).

Table 7-6 shows the same trends at the level of the more disaggregated land-use categories. The data is resulting from interpolation and extrapolation in time and from spatial stratification (altitude classes and soil types). For example, the area of afforestations (combination category 11) decreases in all altitude classes between 65.1% and 100% from 1990 to 2010, while the area of managed forests (combination category 12) increases by 3.7% since 1990 in an altitude over 1200 m.

Table 7-6 Statistics of land use (CC = combination categories) for the whole period 1990-2010 (in ha) and change (absolute and relative) between 1990 and 2010. The table displays the data for the land-use categories remaining the same land-use category (excluding land converted to a specific category).

CC	altitude	soil type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
11	≤ 600	n.s.	8.5	9.1	9.7	10.2	10.8	11.4	12.0	10.7	9.3	8.0	6.7	5.3	4.0
	601-1200	n.s.	7.0	6.0	5.0	4.0	3.0	2.0	1.0	1.3	1.7	2.0	2.3	2.7	3.0
	> 1200	n.s.	29.0	29.5	30.0	30.5	31.0	31.5	32.0	28.8	25.7	22.5	19.3	16.2	13.0
12	≤ 600	n.s.	993.5	993.9	994.4	994.8	995.2	995.6	996.0	995.8	995.7	995.5	995.3	995.2	995.0
	601-1200	n.s.	1954.5	1955.4	1956.3	1957.2	1958.2	1959.1	1960.0	1958.0	1956.0	1954.0	1952.0	1950.0	1948.0
	> 1200	n.s.	2157.5	2164.1	2170.7	2177.2	2183.8	2190.4	2197.0	2199.5	2202.0	2204.5	2207.0	2209.5	2212.0
13	≤ 600	n.s.	0.5	0.6	0.7	0.7	0.8	0.9	1.0	0.8	0.7	0.5	0.3	0.2	0.0
	601-1200	n.s.	8.5	8.6	8.7	8.8	8.8	8.9	9.0	9.3	9.7	10.0	10.3	10.7	11.0
	> 1200	n.s.	876.5	881.3	886.0	890.8	895.5	900.3	905.0	907.7	910.3	913.0	915.7	918.3	921.0
21	n.s.	mineral	1828.5	1823.7	1819.0	1814.2	1809.5	1804.7	1800.0	1793.3	1786.7	1780.0	1773.3	1766.7	1760.0
	n.s.	organic	124.0	123.8	123.7	123.5	123.3	123.2	123.0	122.7	122.3	122.0	121.7	121.3	121.0
31	≤ 600	mineral	1132.0	1124.5	1117.0	1109.5	1102.0	1094.5	1087.0	1084.5	1082.0	1079.5	1077.0	1074.5	1072.0
	≤ 600	organic	63.0	62.7	62.3	62.0	61.7	61.3	61.0	61.0	61.0	61.0	61.0	61.0	61.0
	601-1200	mineral	364.5	362.6	360.7	358.8	356.8	354.9	353.0	351.8	350.7	349.5	348.3	347.2	346.0
	601-1200	organic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	> 1200	mineral	1666.5	1663.1	1659.7	1656.2	1652.8	1649.4	1646.0	1646.0	1646.0	1646.0	1646.0	1646.0	1646.0
	> 1200	organic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	≤ 600	n.s.	20.0	20.2	20.3	20.5	20.7	20.8	21.0	21.5	22.0	22.5	23.0	23.5	24.0
	601-1200	n.s.	9.5	9.3	9.0	8.8	8.5	8.3	8.0	8.2	8.3	8.5	8.7	8.8	9.0
	> 1200	n.s.	563.0	556.0	549.0	542.0	535.0	528.0	521.0	519.3	517.7	516.0	514.3	512.7	511.0
33	n.s.	mineral	30.5	30.7	31.0	31.2	31.5	31.7	32.0	32.2	32.3	32.5	32.7	32.8	33.0
	n.s.	organic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	≤ 600	n.s.	382.5	380.9	379.3	377.8	376.2	374.6	373.0	366.7	360.3	354.0	347.7	341.3	335.0
	601-1200	n.s.	79.5	79.1	78.7	78.2	77.8	77.4	77.0	76.0	75.0	74.0	73.0	72.0	71.0
	> 1200	n.s.	255.0	255.2	255.3	255.5	255.7	255.8	256.0	255.0	254.0	253.0	252.0	251.0	250.0
35	n.s.	mineral	0.5	0.4	0.3	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	n.s.	organic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	n.s.	n.s.	346.5	345.4	344.4	343.3	342.2	341.1	340.0	341.3	342.7	344.0	345.3	346.7	348.0
37	n.s.	n.s.	398.5	396.6	394.7	392.7	390.8	388.9	387.0	385.7	384.3	383.0	381.7	380.3	379.0
41	n.s.	n.s.	198.5	195.4	192.3	189.3	186.2	183.1	180.0	186.2	192.3	198.5	204.7	210.8	217.0
42	n.s.	n.s.	160.0	160.2	160.3	160.5	160.7	160.8	161.0	161.3	161.7	162.0	162.3	162.7	163.0
51	n.s.	n.s.	903.5	916.6	929.7	942.8	955.8	968.9	982.0	997.5	1013.0	1028.5	1044.0	1059.5	1075.0
52	n.s.	n.s.	304.5	306.4	308.3	310.2	312.2	314.1	316.0	318.7	321.3	324.0	326.7	329.3	332.0
53	n.s.	n.s.	15.0	14.3	13.7	13.0	12.3	11.7	11.0	12.2	13.3	14.5	15.7	16.8	18.0
54	n.s.	n.s.	143.5	146.4	149.3	152.2	155.2	158.1	161.0	160.2	159.3	158.5	157.7	156.8	156.0
61	n.s.	n.s.	1025.5	1028.1	1030.7	1033.2	1035.8	1038.4	1041.0	1036.8	1032.7	1028.5	1024.3	1020.2	1016.0
Sum			16050	16050	16050	16050	16050	16050	16050	16050	16050	16050	16050	16050	16050

CC-code	altitude	soil type	2003	2004	2005	2006	2007	2008	2009	2010	Change 1990-2010 (ha)	Change 1990-2010 (%)
11	≤ 600	n.s.	3.3	2.7	2.0	1.3	0.7	0.0	0.0	0.0	-8.5	-100%
	601-1200	n.s.	2.7	2.3	2.0	1.7	1.3	1.0	0.7	0.3	-6.7	-95.2%
	> 1200	n.s.	12.8	12.7	12.5	12.3	12.2	12.0	11.1	10.1	-18.9	-65.1%
12	≤ 600	n.s.	994.7	994.3	994.0	993.7	993.3	993.0	993.0	992.9	-0.6	-0.1%
	601-1200	n.s.	1947.7	1947.3	1947.0	1946.7	1946.3	1946.0	1945.5	1945.1	-9.4	-0.5%
	> 1200	n.s.	2215.0	2218.0	2221.0	2224.0	2227.0	2230.0	2234.0	2238.1	80.6	3.7%
13	≤ 600	n.s.	0.2	0.3	0.5	0.7	0.8	1.0	1.0	1.1	0.6	111.9%
	601-1200	n.s.	11.0	11.0	11.0	11.0	11.0	11.0	11.1	11.3	2.8	32.6%
	> 1200	n.s.	923.7	926.3	929.0	931.7	934.3	937.0	940.4	943.7	67.2	7.7%
21	n.s.	mineral	1745.0	1730.0	1715.0	1700.0	1685.0	1670.0	1661.2	1652.4	-176.1	-9.6%
	n.s.	organic	120.5	120.0	119.5	119.0	118.5	118.0	117.7	117.3	-6.7	-5.4%
31	≤ 600	mineral	1076.8	1081.7	1086.5	1091.3	1096.2	1101.0	1099.3	1097.6	-34.4	-3.0%
	≤ 600	organic	61.5	62.0	62.5	63.0	63.5	64.0	64.1	64.1	1.1	1.8%
	601-1200	mineral	345.3	344.7	344.0	343.3	342.7	342.0	340.8	339.5	-25.0	-6.9%
	601-1200	organic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	> 1200	mineral	1642.8	1639.7	1636.5	1633.3	1630.2	1627.0	1624.8	1622.6	-43.9	-2.6%
	> 1200	organic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
32	≤ 600	n.s.	24.2	24.3	24.5	24.7	24.8	25.0	25.3	25.6	5.6	27.8%
	601-1200	n.s.	9.5	10.0	10.5	11.0	11.5	12.0	12.1	12.3	2.8	29.2%
	> 1200	n.s.	512.2	513.3	514.5	515.7	516.8	518.0	515.5	513.0	-50.0	-8.9%
33	n.s.	mineral	33.0	33.0	33.0	33.0	33.0	33.0	33.1	33.3	2.8	9.1%
	n.s.	organic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
34	≤ 600	n.s.	330.7	326.3	322.0	317.7	313.3	309.0	304.9	300.8	-81.7	-21.4%
	601-1200	n.s.	71.5	72.0	72.5	73.0	73.5	74.0	73.7	73.4	-6.1	-7.7%
	> 1200	n.s.	248.8	247.7	246.5	245.3	244.2	243.0	242.3	241.7	-13.3	-5.2%
35	n.s.	mineral	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.6	-111%
	n.s.	organic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
36	n.s.	n.s.	346.5	345.0	343.5	342.0	340.5	339.0	338.6	338.2	-8.3	-2.4%
37	n.s.	n.s.	377.3	375.7	374.0	372.3	370.7	369.0	367.4	365.7	-32.8	-8.2%
41	n.s.	n.s.	214.7	212.3	210.0	207.7	205.3	203.0	203.3	203.5	5.0	2.5%
42	n.s.	n.s.	162.5	162.0	161.5	161.0	160.5	160.0	160.0	160.0	0.0	0.0%
51	n.s.	n.s.	1089.7	1104.3	1119.0	1133.7	1148.3	1163.0	1177.4	1191.8	288.3	31.9%
52	n.s.	n.s.	338.0	344.0	350.0	356.0	362.0	368.0	371.5	375.1	70.6	23.2%
53	n.s.	n.s.	18.7	19.3	20.0	20.7	21.3	22.0	22.4	22.8	7.8	51.8%
54	n.s.	n.s.	153.0	150.0	147.0	144.0	141.0	138.0	137.7	137.4	-6.1	-4.3%
61	n.s.	n.s.	1016.8	1017.7	1018.5	1019.3	1020.2	1021.0	1020.8	1020.5	-5.0	-0.5%
Sum			16050	16050	16050	16050	16050	16050	16050	16051	0.9	0.0%

The mean annual rates of change in the whole country (change-matrix) are achieved by adding up the mean annual change rates of all hectares per combination category (CC). Table 7-7 shows an overview of the mean annual changes of all CC in 1990 as an example (see Table A - 7 and Table A - 8 for further matrixes 1989-1990 and 1999-2000. The totals of the columns are equal to the total increase of one specific category. The totals of the rows are equal to the total decrease of one specific category. The sum of increases and decreases is identical.

For calculating the carbon stock changes, these fully stratified land-use change matrices are used for each year (see section 7.2.3.).

Table 7-7 Land-use change between 2008 and 2010 (change matrix). Units: ha/year.

From \ To			11			12			13			21		31						32			33		34			35		36	37	41	42	51	52	53	54	61	Decrease
CC-code	altitude zone z	soil type	1	2	3	1	2	3	1	2	3	n.s.	n.s.	1	1	2	2	3	3	1	2	3	n.s.	n.s.	1	2	3	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	
			n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0	1	0	1	0	1	0	1	n.s.	n.s.	n.s.	0	1	n.s.	n.s.	n.s.	0	1	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	
11	1	n.s.	0	0	0	0.47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
	2	n.s.	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
	3	n.s.	0	0	0	0	0	1	0	0	0.11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1
12	1	n.s.	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	1	0.17	0	0.17	0.17	2.2
	2	n.s.	0	0	0	0	0	0	0	0.86	0	0	0	0	0	0	0	0	0	0	0.67	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	2.0
	3	n.s.	0	0	0	0	0	0	0	0	1.17	0	0	0	0	0	0	0.5	0	0	0	0.64	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0.17	3.5
13	1	n.s.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
	2	n.s.	0	0	0	0	0.72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7
	3	n.s.	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1.08	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33	5.4
21	n.s.	0	0	0	0	0	0	0	0	0	0	0	0	7.97	0	0	0	0	0	0	0	0	0	0	0.33	0	0	0	0	0.33	0	0	1	1.67	1.67	0	0	0	13.0
	n.s.	1	0	0	0	0	0	0	0	0	0	0	0	0	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3
31	1	0	0	0	0	0	0	0	0	0	0	3.67	0	0	0	0	0	0	0	0.33	0	0	0.17	0	1.67	0	0	0	0	0	0.17	0	0	7.19	2.33	0	0	0	15.5
	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.45	0	0	0	0	0	0.4
	2	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.42	0	0	0	0	0.67	0	0	0	0	0	0	0	0.33	0.5	0	0	0	2.1
	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	3	0	0	0	0	0	0	0	0	0	2.17	0	0	0	0	0	0	0	0	0	0	3.53	0	0	0	0	0	0	0	1.3	0	0	0	0.5	0.17	0	0	0.81	8.5
	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
32	1	n.s.	0	0	0	0.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0.49	1.6
	2	n.s.	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0	1.28	0	0	0	0	0	0	0	0	0	0	0	0	1.6
	3	n.s.	0	0	0	0	0	1.5	0	0	5	0	0	0	0	0	0	1.83	0	0	0	0	0	0	0	0	1	0	0	0.5	1	0	0	0	0	0	0	1	11.8
33	n.s.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
	n.s.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
34	1	n.s.	0	0	0	0.33	0	0	0	0	0	0.17	0	4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	1.5	0.65	0	0	0	7.6
	2	n.s.	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.92	0	0.17	0.17	0	0	0	2.8
	3	n.s.	0	0	0	0	0	2	0	0	0.17	0	0	0	0	0	0	0.17	0	0	0	0.33	0	0	0	0	0	0	0	0.17	0.17	0	0	0	0	0	0	0	3.0
35	n.s.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	n.s.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
36	n.s.	n.s.	0	0	0.17	0	0	0	0	0	0.17	0	0	0.33	0	0	0	2.03	0	0.17	0.33	1.5	0	0	0	0	0.33	0	0	0	1.67	0	0	0	0	0	0	1.33	8.0
37	n.s.	n.s.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.33	0.17	2.33	0	0	0.33	0	0	0	0	0	0	0	0	0.95	0	0	0	0.03	5.1
41	n.s.	n.s.	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0	3.45	3.8
42	n.s.	n.s.	0	0	0	0.5	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0.78	0	1.6
51	n.s.	n.s.	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0.33	0	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0.17	0	1.83	1.17	0	0	4.2
52	n.s.	n.s.	0	0	0	0	0	0	0	0	0	0	0	0.33	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.33	0	0	1.67	0	5.5
53	n.s.	n.s.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.28	0.17	0	0.33	0	0.8
54	n.s.	n.s.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0	0	1.5	1.38	0	0	0.2	3.3
61	n.s.	n.s.	0	0	0	0	0	0	0	0	0	0.33	0	0.33	0.17	0	0	0.17	0	0	0.17	0	0	0	0	0	0	0	0	5.15	0	1.95	0	0	0	0	0	0	8.3
Increase			0.0	0.2	0.2	2.1	1.6	7.5	0.2	0.9	8.8	4.2	0.0	13.8	0.5	0.8	0.0	6.3	0.0	1.8	1.8	9.3	0.3	0.0	3.6	2.4	2.3	0.0	0.0	7.6	3.5	4.0	1.6	18.6	9.0	1.2	2.9	8.0	125.0

Land-use changes between two categories of unmanaged land (e.g. stony and unproductive grassland) are not human induced and are therefore not considered. Due to IPCC Good Practice Guidance LULUCF (2003): *"Carbon stock changes and greenhouse gas emissions on unmanaged land are not reported under the IPCC Guidelines, although reporting is required when unmanaged land is subject to land use conversion"* (chapter 2 Basis for consistent representation of land areas[15]).

7.2.5 Carbon Emission Factors and Stocks at a Glance

Table 7-8 lists all values of carbon stocks, increases, decreases and net changes of carbon specified for land-use category (CC) and associated spatial strata for the year 1990 (FOEN 2006a). These values remain constant during the period 1990-2010 (with the exception of carbon stock of afforestations and of managed forests, which are increasing every year due to annual net growth).

[15] www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp2/Chp2_Land_Areas.pdf

Table 7-8 Carbon stocks and changes in biomass, dead organic matter and soils for the combination categories (CC), disaggregated for altitude and soil type. These values are valid for the whole period 1990-2010 (no annual changes) (FOEN 2006a).

CC-code	altitude zone z	soil type	carbon stock in living biomass (stockCl,i) 1990	carbon stock in dead organic matter (stockCd,i)	carbon stock in soil (stockCs,i)	growth of living biomass (increaseCl,i)	harvesting of living biomass (decreaseCl,i)	net change in dead organic matter (changeCd,i)	net change in soil (changeCs,i)
	Strata		Stocks (t C ha-1)			Changes (t C ha-1 yr-1)			
11	1	n.s.	12.35	0	75.30	2.56	0	0	0
	2	n.s.	6.70	0	75.30	1.70	0	0	0
	3	n.s.	2.41	0	75.30	0.85	0	0	0
12	1	n.s.	156.80	4.45	92.70	4.49	-3.05	0	0
	2	n.s.	152.16	4.01	92.70	4.18	-3.11	0	0
	3	n.s.	116.23	3.98	92.70	2.52	-2.06	0	0
13	1	n.s.	41.41	0	92.70	0	0	0	0
	2	n.s.	43.01	0	92.70	0	0	0	0
	3	n.s.	26.23	0	92.70	0	0	0	0
21	n.s.	0	5.66	0	53.40	0	0	0	0
	n.s.	1	5.66	0	240.00	0	0	0	-9.52
31	1	0	7.45	0	62.02	0	0	0	0
	1	1	7.45	0	240.00	0	0	0	-9.52
	2	0	6.26	0	67.50	0	0	0	0
	2	1	6.26	0	240.00	0	0	0	-9.52
	3	0	4.45	0	75.18	0	0	0	0
	3	1	4.45	0	240.00	0	0	0	-9.52
32	1	n.s.	11.60	0	68.23	0	0	0	0
	2	n.s.	11.60	0	68.23	0	0	0	0
	3	n.s.	11.60	0	68.23	0	0	0	0
33	n.s.	0	3.74	0	53.40	0	0	0	0
	n.s.	1	3.74	0	240.00	0	0	0	-9.52
34	1	n.s.	11.60	0	68.23	0	0	0	0
	2	n.s.	11.60	0	68.23	0	0	0	0
	3	n.s.	11.60	0	68.23	0	0	0	0
35	n.s.	0	24.63	0	64.76	0	0	0	0
	n.s.	1	24.63	0	240.00	0	0	0	-9.52
36	n.s.	n.s.	4.06	0	26.31	0	0	0	0
37	n.s.	n.s.	6.05	0	68.23	0	0	0	0
41	n.s.	n.s.	0	0	0	0	0	0	0
42	n.s.	n.s.	7.96	0	154.00	0	0	0	0
51	n.s.	n.s.	0	0	0	0	0	0	0
52	n.s.	n.s.	5.80	0	53.40	0	0	0	0
53	n.s.	n.s.	4.80	0	53.40	0	0	0	0
54	n.s.	n.s.	4.80	0	53.40	0	0	0	0
61	n.s.	n.s.	0	0	0	0	0	0	0

Legend

altitude zones:		*soil type:*		n.s. = no stratification
1	< 600 m	0	mineral soil	
2	601 - 1200 m	1	organic soil	
3	> 1200 m			

On organic soils, a value of 240 t C ha^{-1} for stock C_s was assumed for all land-use categories (FOEN 2011, p. 257, based on Leifeld et al. (2003, 2005) . Where no stratification according to soil type is indicated (e.g. in CC 11,12,13), all soils including organic soils are allocated to mineral soils. Thus, when calculating carbon changes in organic soils as a consequence of land-use changes, the difference of carbon stocks is always zero.

Carbon stock data for forests are derived from monitoring data of the Swiss National Forest Inventory NFI I; NFI II and NFI III. The data for agriculture, grassland and settlements are based on experiments, field studies, literature and expert estimates from Switzerland. For wetlands and other land, expert estimates or default values are available. The deduction of the individual values is explained in the following chapters.

7.3 Source Category 5A – Forest Land

7.3.1 Source Category Description

Key source 5A1
CO_2 emissions and removals from 5A1 Forest Land remaining Forest land are a key source by level and trend. Source category 5A2 “Land converted to Forest Land” is not a key source.

38% of the total area of Liechtenstein is forest land. The total area of forest land increased by 1.8% between 1990 and 2010. The annual net CO_2 removals range from 18.34 Gg CO_2 (2003) to 19.68 Gg CO_2 (1997). The source category 5A1 “Forest Land remaining Forest Land” is by far the most relevant source category accounting for over 99% of net CO_2 removals from forest land.

All of the forest land is temperate forest. The definition of forest land is originally based on the Swiss definition and was revised after the In-Country Reviews carried out in Switzerland and Liechtenstein 2007. Forest land is now defined as follows (OEP 2007b):

- Minimum area of land: 0.0625 hectares with a minimum width of 25 m
- Minimum crown cover: 20%
- Minimum height of the dominant trees: 3 m (dominant trees must have the potential to reach 3 m at maturity in situ)

For reporting in the CRF tables, forest land was subdivided into afforestations (CC 11), managed forest (CC 12) and unproductive forest (CC 13) based on the land use and land cover categories (see Table 7-3, FOEN 2006b; SFSO 2006a).

7.3.2 Methodological Issues

7.3.2.1 Forest Land remaining Forest Land (5A1)

The activity data collection follows the methods described in chapter 7.2.2. Carbon stocks and carbon stock changes are taken from Switzerland. Details are described in the following paragraphs.

a) Swiss National Forest Inventories (NFI)

Data for growing stock, gross growth, cut (harvesting), and mortality was derived from the first and the second Swiss National Forest Inventory (see Table 7-9). The NFI I was conducted between 1983 and 1985 (EAFV/BFL 1988), the NFI II was conducted between 1993 and 1995 (Brassel and Brändli 1999).

Table 7-9 Characteristics of the Swiss National Forest Inventories I, II and III.

	NFI I	NFI II	NFI III
Inventory cycle	1983-1985	1993-1995	2004-2006
Grid size	1 x 1 km^2	1.4 x 1.4 km^2	1.4 x 1.4 km^2
Terrestrial sample plots	~12'000	~6'000	~6'000
Measured single trees	~130'000	~70'000	~70'000

b) Stratification, Spatial strata

As in Switzerland, forests in Liechtenstein reveal a high heterogeneity in terms of elevation, growth conditions, and tree species composition. To find explanatory variables that significantly reduce the variance of gross growth and biomass expansion factors (BEFs) an analysis of variance was done in Switzerland (Thürig and Schmid 2007). The explanatory variables considered are (see also 7.2.3):

- altitude (≤ 600 m, 601-1200 m, > 1200 m)
- tree species (coniferous and deciduous species).

In Liechtenstein, most forests are mixed stands. It was assumed that the mix between coniferous and deciduous species in different altitudes is identical as in the prealpine region of Switzerland (no national data considered).

In Switzerland, the forest area derived by the land use statistics does not allow separating coniferous and deciduous sites. If species specific measures for growing stock, gross growth, harvesting and BEFs are to be applied, the total forest area has to be divided according to the species mixture. It was assumed that the space asserted by a single tree is highly correlated with its basal area. The required ratio of coniferous forest area (R_c) per spatial stratum (Table 7-10) was calculated by dividing the sum of the basal area of the conifers (BA_c) over the sum of the basal area of all trees (BA).

$R_{ci} = BA_{ci} / BA_i$ i = spatial strata

As both species add up to 1 (or 100%) the rate of deciduous forest area (R_d) is:

$R_{di} = 1 - R_{ci}$ i = spatial strata

The following Swiss ratio of coniferous and deciduous species per altitude class was applied:

Table 7-10 Ratio of coniferous and deciduous species (source: NFI II; Brassel and Brändli 1999).

Altitude [m]	Coniferous	Deciduous
≤ 600	0.395	0.605
601-1200	0.713	0.287
> 1200	0.925	0.075

c) Biomass Expansion Factors (BEF)

The Swiss Biomass Expansion Factors were applied in Liechtenstein (FOEN 2008).

In the Swiss National Forest Inventory, growing stock, gross growth, cut (harvesting) and mortality is expressed as round wood over bark. Round wood over bark was expanded to total biomass as done in Thürig et al. (2005) by applying allometric single-tree functions to all trees measured at the NFI II. BEFs were then calculated for each spatial stratum as the ratio between round wood over bark (m^3 ha^{-1}) and the total above- and belowground biomass (t ha^{-1}). Table 7-11 shows the BEFs for coniferous and deciduous species stratified for altitude.

Table 7-11 Biomass expansion factors (BEFs) to convert round-wood over bark (m^3 C ha^{-1}) to total biomass (t C ha^{-1}) for conifers and deciduous species, respectively (Thürig et al. 2005).

Altitude [m]	Conifers		Deciduous species	
	Number of trees measured	BEFs	Number of trees measured	BEFs
≤ 600	129	1.48	239	1.49
601-1200	4220	1.48	1980	1.49
> 1200	2909	1.59	241	1.56

d) Wood Densities

To convert round wood over bark (m^3 ha^{-1}) into t ha^{-1} it was multiplied by a species-specific density. Table 7-12 shows the applied densities.

Table 7-12 Wood densities for coniferous and deciduous trees (Vorreiter 1949).

	Wood density [t m^{-3}]
Coniferous trees	0.4
Deciduous trees	0.55

e) Carbon Content

The IPCC default carbon content of solid wood of 50% was applied (IPCC 2003; p. 3.25).

f) Growing Stock, Gross Growth and Cut & Mortality in Managed Forests (CC 12)

The Swiss values for growing stock, gross growth, cut and mortality were applied in Liechtenstein (FOEN 2008).

Growing stock, gross growth, cut and mortality for managed forests were derived from those 5’425 sample plots measured at both Swiss National Forest Inventories NFI I and NFI II (Kaufmann 2001). All values derived from the NFI I and II are related to round wood over bark (with stock, without branches) and are given in m^3 ha^{-1} per spatial stratum (see Table 7-13 and Table 7-14).

Table 7-13 Growing stock, gross growth, cut and mortality for coniferous trees (related to coniferous forest area).

Coniferous trees				
Altitude [m]	Growing stock 1985 [m^3 ha^{-1}]	Growing stock 1995 [m^3 ha^{-1}]	Gross growth [m^3 ha^{-1} 10.1yr^{-1}]	Cut and mortality [m^3 ha^{-1} 10.1yr^{-1}]
≤ 600	473.58	506.79	132.36	99.14
601-1200	482.43	515.95	132.71	98.85
> 1200	356.09	372.59	76.12	59.58

Note: 10.1 years correspond to the average inter-survey period between NFI I and NFI II; see below.

Table 7-14 Growing stock, gross growth, cut and mortality for deciduous trees (related to deciduous forest area).

Deciduous trees				
Altitude [m]	**Growing stock 1985 [m^3 ha^{-1}]**	**Growing stock 1995 [m^3 ha^{-1}]**	**Gross growth [m^3 ha^{-1}10.1yr^{-1}]**	**Cut and mortality [m^3 ha^{-1} 10.1yr^{-1}]**
≤ 600	379.93	427.12	115.75	68.56
601-1200	374.75	427.88	113.4	60.82
>1200	257.27	311.7	72.32	17.88

Note: 10.1 years correspond to the average inter-survey period between NFI I and NFI II; see below.

Conversion of NFI data to annual estimates of gross growth and cut & mortality

The average inter-survey period between the Swiss NFI I and NFI II is not exactly 10 years, but 10.1 years. With regard to the individual spatial strata, the variance is even larger (Table 7-15).

Table 7-15 Average inter-survey period [in years] between NFI I and NFI II for all spatial strata.

Altitude		
≤ 600 m	**601 m-1200 m**	**> 1200 m**
10.4	10.1	10.0

To convert gross growth and cut & mortality measured between NFI I and II into average annual gross growth and average annual cut & mortality, those data had to be divided by the time periods shown in Table 7-15

[annual gross growth $_i$ = [gross growth between NFI I and II] $_i$ / time period $_i$

[annual cut & mortality] $_i$ = [cut & mortality between NFI I and II] $_i$ / time period $_i$

where i indicates the different altitudes.

Annual cut and mortality

In order to simplify the estimation of annual cut and mortality, it is assumed that the annual cut and mortality is constant over the whole time period. This is in difference to the Swiss calculation, where different annual cut and mortality amounts are estimated. Liechtenstein applies the Swiss values for the year 1990 for all years between 1990 and 2010.

To calculate the annual cut and mortality (CMy) for the year 1990, the total amount of cut and mortality was distributed among the ten years between 1986 and 1995 and weighted by the percentage of the annual harvesting amounts taken from the forest statistic (SFSO 2006b, SAEFL 2005b).

The annual cut and mortality for coniferous and deciduous trees is as follows:

Table 7-16 Annual cut and mortality for coniferous trees in m^3 ha^{-1} and t C ha^{-1} (value for 1990, applied for all years).

Coniferous trees		
Altitude [m]	**Annual cut and mortality [m^3 ha^{-1}]**	**Annual cut and mortality [t C ha^{-1}]**
≤ 600	11.34	3.36
601-1200	11.3	3.35
> 1200	6.81	2.17

Table 7-17 Annual cut and mortality for deciduous trees in $m^3 ha^{-1}$ and t C ha^{-1} (value for 1990, applied for all years).

Deciduous trees		
Altitude [m]	**Annual cut and mortality [$m^3 ha^{-1}$]**	**Annual cut and mortality [t C ha^{-1}]**
≤ 600	6.95	2.85
601-1200	6.16	2.53
> 1200	1.81	0.78

Gross growth

It is assumed that the growth rate of living biomass is constant over the whole time period. Liechtenstein applies the Swiss annual growth values for the year 1990 for all the years between 1990 and 2010. These values are displayed in Table 7-18.

$x_{j,i} = x_{j,i-1}$ + annual growth of living mass in altitude j (constant) – annual harvesting of living mass in altitude j (constant); i runs from 1991 to 2010.

Table 7-18 Growing stock of managed forests (CC12) 1990-2010 in t C ha^{-1}.

Growing C stocks of managed forests (CC 12) 1990-2010													
Altitude	**carbon stock in living biomass (stockCl,i)**												
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
≤ 600 m	156.8	158.2	159.7	161.1	162.6	164.0	165.5	166.9	168.3	169.8	171.2	172.7	174.1
601-1200 m	152.2	153.2	154.3	155.4	156.4	157.5	158.6	159.7	160.7	161.8	162.9	163.9	165.0
> 1200 m	116.2	116.7	117.1	117.6	118.1	118.5	119.0	119.5	119.9	120.4	120.8	121.3	121.8

Altitude	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**annual growth of living biomass (increase)**	**annual harvesting of living biomass (decrease)**	**Δ annual change**
≤ 600 m	175.6	177.0	178.4	179.9	181.3	182.8	184.2	185.7	4.5	-3.05	1.44
601-1200 m	166.1	167.2	168.2	169.3	170.4	171.4	172.5	173.6	4.2	-3.11	1.07
> 1200 m	122.2	122.7	123.1	123.6	124.1	124.5	125.0	125.4	2.5	-2.06	0.46

g) Growing C Stocks in Unproductive Forests (CC 13)

The unproductive forest in Liechtenstein mainly consists of brush forest and inaccessible forest. Although unproductive, this type of forest is still categorized as managed forest. The same carbon stock per hectare as in Switzerland is assumed.

Brush forest

No data from the Swiss National Forest Inventory (NFI) are available to derive their growing stock. Brush forests mainly consist of Alnus viridis and horizontal Pinus mugo var. prostrate. Therefore, following estimations were made:

Average growing stock: 4000 trees per ha, average height of 2.5 m and an average diameter at 1.3 m of 10 cm. Hence, an average growing stock (> 7 cm diameter) of 40 $m^3 ha^{-1}$ was estimated (FOEN 2011),

Wood density for coniferous trees: 0.4 t m^{-3} (Vorreiter 1949)

BEF: 1.45 (Burschel et al. 1993)

Carbon content: 50% (IPCC default carbon content)

Carbon stock : 11.6 t C ha $^{-1}$ = 40 m^3 ha $^{-1}$ * 0.4t m^{-3} * 1.45 * 0.5

(C stock in living biomass = Average growing stock * density * BEF * C-content)

Inaccessible forest

Inaccessible forest in Liechtenstein is mainly located in higher altitudes (above 1200 m). No data from the Swiss National Forest Inventory (NFI) are available to derive the stock growth. Therefore, the following assumptions were made:

Average growing stock: Inaccessible forest is located in the Alps where the average growing stock is around 318 m^3 ha-1 and 219 m^3 ha $^{-1}$, respectively (Brassel and Brändli 1999). As those forests are assumed to grow preferably on bad site conditions, an average growing stock (> 7 cm diameter) of 150 m^3 ha $^{-1}$ was estimated.

Wood density for coniferous trees: 0.4 t m^{-3} (Vorreiter 1949)

BEF: 1.45 (Burschel et al. 1993)

Carbon content: 50% (IPCC default carbon content)

Carbon stock : 43.5 t C ha $^{-1}$ = 150 m^3 ha $^{-1}$ * 0.4t m^{-3} * 1.45 * 0.5

(C stock in living biomass = Average growing stock * density * BEF * C-content)

Carbon content of unproductive forests (CC 13): Weighted means

The carbon content of unproductive forest was calculated as a weighted average of brush forest and inaccessible forest per spatial stratum:

$[\text{weighted C content}]_i = RS_i * CS + (1- RS_i) * CI$

where RS_i is the rate of the brush forest per spatial stratum i,

CS is the carbon content of brush forest (11.6 t C ha^{-1}),

CI is the carbon content of inaccessible forest (43.5 t C ha^{-1}).

Table 7-19 shows the carbon content per altitude class in t C ha^{-1}.

Table 7-19 Rate of brush forest and inaccessible forest and the resulting weighted carbon content in t C ha-1 of Swiss unproductive forests (CC 13) specified for all spatial strata.

Altitude [m]	Rate of brush forest	Rate of inaccessible forest	Weighted C content [t C ha^{-1}]
≤ 600	0.066	0.934	41.41
601-1200	0.015	0.985	43.01
> 1200	0.541	0.459	26.23

* Derived from the NFI II (Brassel and Brändli 1999)

g) Dead Wood in managed forests (CC 12)

The Swiss carbon stock amounts per hectare are applied in Liechtenstein.

In the second Swiss NFI, all dead trees (standing and lying) larger than 12 cm in diameter were measured. Thus, an estimate of the dead-wood pool in Swiss managed forests (CC 12) can be done.

Table 7-20 Dead wood in Swiss managed forests (CC12) (Brassel and Brändli 1999).

	Dead wood [m^3 ha^{-1}]
Lying trees	3.7
Standing trees	8.4
Total	12.2

Applying the same wood densities, BEFs and carbon content as for the living growing stock, dead wood per spatial stratum can be estimated (Table 7-21).

Table 7-21 Dead wood in managed forests (CC12) per altitude class in t C ha-1.

Altitude [m]	**Carbon in dead biomass [t C ha^{-1}]**
≤ 600	4.45
601-1200	4.01
> 1200	3.98

g) Carbon Stock of Afforestations (CC 11)

Growing stock and growth

The Swiss growing stock and growth rates are applied in Liechtenstein. The following paragraph gives some further explanations about the Swiss calculation of carbon stock changes.

Swiss methodology (excerpt from NIR CH, chpt. 7.3.2, FOEN 2007):

The average growing stock and growth of afforestations were empirically assessed with NFI I and II, specifically with those stands that were approximately 10 years old in the first NFI and 20 years old in the second NFI. The average growing stock of those 20 year old stands was derived from NFI II. The NFI data were therefore stratified for site quality. It was assumed that forest areas below 600 m show a good site quality, areas between 600 and 1200 m a moderate site quality, and forest areas above 1200 m show a poor site quality. The growing stock of forest stands on good sites was 90 m^3 ha^{-1}. The growing stock on moderate sites was assumed to be one-third smaller than on good sites (60 m^3 ha^{-1}), and two-third smaller on bad sites (30 m^3 ha^{-1}). As trees below 12 cm DBH were not measured in the NFI, the growing stock of 10 year old stands on good sites was assumed to be 2 m^3 ha^{-1}. Within the first few years of stand age, the growing stock was assumed to develop exponentially. The development of the growing stock on good sites between 10 and 20 years was therefore simulated by calibrating an exponential growth function. To simulate the development of growing stock on intermediate and poor sites, growing stock was assumed to develop one-third slower on intermediate, and two-third slower on poor sites. The annual growth was calculated as the difference between growing stocks of two following years. These assumptions are not valid for single stands, but can be applied as a rough simplification[16].

[16] As these assumptions stem from a modeling approach with a growth function (based on the LFI's), they cannot be used in a small scale, isolated observation, as for example for small patches of forest (single stands).

Table 7-22 *shows the simulated growing stock and growth for all three site qualities.*

Table 7-22 Estimated average growing stock and annual growth of forest stands in stemwood (defined in Table 24) up to 20 years (CC11) specified for altitude zone.

Stand age *[yr]*	***≤ 600 m altitude***		***601 - 1200 m altitude***		***> 1200 m altitude***	
	Growing stock *[m^3ha^{-1}]*	***Growth*** *[m^3 ha^{-1} $year^{-1}$]*	***Growing stock*** *[m^3ha^{-1}]*	***Growth*** *[m^3 ha^{-1} $year^{-1}$]*	***Growing stock*** *[m^3ha^{-1}]*	***Growth*** *[m^3 ha^{-1} $year^{-1}$]*
0-9	*0*	*0*	*0*	*0*	*0*	*0*
10	***2***	*2*	*0*	*0*	*0*	*0*
11	*7*	*5*	*0*	*0*	*0*	*0*
12	*13*	*6*	*1*	*1*	*0*	*0*
13	*19*	*6*	*5*	*4*	*0*	*0*
14	*27*	*8*	*10*	*5*	*0*	*0*
15	*35*	*8*	*16*	*6*	*1*	*1*
16	*44*	*9*	*23*	*7*	*5*	*4*
17	*54*	*10*	*31*	*8*	*10*	*5*
18	*66*	*12*	*40*	*9*	*16*	*6*
19	*78*	*12*	*50*	*10*	*23*	*7*
20	***90***	*12*	***60***	*10*	***30***	*7*

To convert the estimated growing stock and growth into carbon, the following equations were applied:

*C stock in living biomass = Average growing stock * density * BEF * C-content*

*Growth of living biomass = Average growth * density * BEF * C-content*

In Table 7-23, abbreviations and units are explained. Table 7-24 shows the parameters and the converted values.

Table 7-23 Conversion of growing stock and growth to total carbon in biomass.

Name	***Description***	***Value***	***Unit***
Average growing stock	*Average growing stock of stemwood over bark, without branches*	*See Table 7-24*	*m^3 ha^{-1}*
Average growth	*Average growth per ha and year*	*See Table 7-24*	*m^3 ha^{-1} $year^{-1}$*
Density	*Tree density averaged for coniferous and deciduous trees*	*0.47*	*t m^{-3}*
BEF	*Biomass expansion factor to convert stemwood over bark into total tree biomass (Burschel et al. 1993); averaged value for coniferous and deciduous trees.*	*1.45*	*-*
C-content	*Carbon to total biomass ratio (IPCC default)*	*0.5*	*-*
C stock in living biomass	*Carbon content in total above- and belowground biomass*	*See Table 7-24*	*t C ha^{-1}*
Growth of living biomass	*Growth of carbon in t C per ha and year*	*See Table 7-24*	*t C ha^{-1} $year^{-1}$*

Table 7-24 Carbon stock in living biomass and growth of living biomass in afforestations (CC11) specified for altitude zone.

Altitude [m]	Average growing stock [m^3 ha^{-1}]	Average growth [m^3 $ha^{-1}year^{-1}$]	Density [$t\ m^{-3}$]	BEF	Carbon content	Carbon stock in living biomass [$t\ C\ ha^{-1}$]	Growth of living biomass [$t\ C\ ha^{-1}\ year^{-1}$]
≤ 600	36.25	7.5	0.47	1.45	0.5	12.35	2.56
601-1200	19.67	5	0.47	1.45	0.5	6.70	1.70
> 1200	7.08	2.5	0.47	1.45	0.5	2.41	0.85

h) Soil carbon in Managed Forests (CC12), Unproductive Forests (CC13) and Afforestations (CC11)

According to a study of Perruchoud et al. (2000), a carbon stock of mineral forest soils of 76 t C ha $^{-1}$ in 0-30 cm topsoil is assumed for the pre-alpine region (which also covers the area of Liechtenstein).

The soil horizons L (litter), F (fermentation) and H (humus) were not included in the soil samples analyzed by Perruchoud et al. (2000). However, especially in forests, those horizons may contain substantial amounts of carbon and should be included in the estimation of forest soil carbon. In a study done by Moeri (2007) soil carbon of organic soil horizons on mineral soils were estimated. According to this study, the soil carbon in these soil horizons in the pre-alpine region, which is relevant for Liechtenstein, is 17.4 t C ha $^{-1}$. Further details are displayed in Table 7-25.

Table 7-25 Soil organic carbon of mineral forest soils (CC12, CC13) in organic soil horizons in t C ha^{-1} in the pre-alpine region. The average values ± standard deviation are given.

	L Horizon	F Horizon	H Horizon	Total
Soil carbon (in t C ha^{-1})	4.4 (± 3.2)	6.4 (± 9.4)	6.6 (± 19.8)	17.4 (± 28.5)

Unlike stated in the GPG LULUCF (IPCC 2003), soil carbon of mineral forest soils in organic soil horizons was added to the soil carbon of the mineral layer for Swiss managed and unproductive forests (CC 12 and CC 13). According to IPCC (2003; Table 3.1.2) soil carbon of the organic soil horizons should be accounted as dead organic matter, together with dead wood.

For afforestations (CC 11), the amount of soil carbon in the soil organic horizons was assumed to be zero. Total soil carbon for afforestated land was defined as soil carbon contained in the 0-30 cm mineral topsoil.

Due to following reasons it is assumed that in the years 1990 to 2010 forest soils in Switzerland as well as in Liechtenstein were no source of carbon:

- Within the last decades, no drastic changes of management practices in forests have been taken place due to restrictive forest laws.
- Fertilization of forests is prohibited in Liechtenstein. Drainage of forests is not common practice in Liechtenstein.
- As growing stock has increased since many years, soil carbon is assumed to increase due to increasing litter production.
- As shown in the study by Thürig et al. (2005), wind-throw may have a slightly increasing effect on soil carbon. However, this study neglected the effect of soil disturbances which could equalize those effects.

i) N_2O Emissions from N Fertilization and Drainage of Soils

Fertilization of forests is prohibited by law in Liechtenstein. Therefore, no emissions are reported in CRF Table 5(I).

Drainage of forests is not common practice in Liechtenstein. As a first guess drainage activity was set to zero, and no emissions are reported for forest land in CRF Table 5(II).

j) Emissions from Wildfires

Controlled burning of forests is not allowed in Liechtenstein. Some information on wildfires affecting forest land is available. It is however not taken into account since the area affected by wildfires in some years is always much below one hectare. Emissions from wildfires are insignificant and are therefore set to zero. No emissions are reported for forest land in CRF Table 5 (V).

7.3.2.2 Land converted to Forest Land (5A2)

Land conversion to forest land is of minor importance in terms of net CO_2 removals. In 2010 only 0.4% of net CO_2 removals from forest land result from a conversion to forest land. According to the land use statistic the areas switching to forest land are mainly areas that used to be grassland or woody biomass (Table 7-7, combination category 32) not fulfilling the definition of minimal forest density and area.

The carbon fluxes in case of land-use change comprising forest land are specified as follows:

According to the stock change approach, the growing stock of e.g. shrub vegetation (CC 32; living biomass and soil carbon) should be subtracted and the average growing stock of forests should be added. However, these forests are supposed to have a growing stock smaller than the growing stock of an average forest and adding the average growing stock of forest areas would possibly overestimate the carbon increase. In terms of IPCC good practice a conservative assumption was met (see also Chapter 7.2.1): The amount of living biomass (carbon stock in living biomass) on land changing from non-forest to forest was not increased but left unchanged. The annual increase of biomass (carbon flux) on these areas was approximated by the annual gross growth rate of the respective forest type (CC 11, 12 or 13). The change of soil carbon was not considered and was set to zero.

Cut and mortality was inferred from the Swiss land-use statistics NFI I and NFI II, applying the stock change approach on forest areas remaining forest. Thus, the total harvesting amount was already considered. To avoid double-counting of the harvesting amount on areas changing from non-forested to forested areas, no additional loss in terms of cut and mortality was accounted for, but the converted areas were only multiplied with the average annual gross growth of the respective spatial stratum.

The annual area of forest changing to other land use categories was also derived by land use statistics. To account for the “decrease of carbon”, above- and belowground biomass, the amount of dead-wood and the amount of soil carbon of forest areas changing into other land use categories were subtracted. To account for the “increase of carbon”, the carbon stock in biomass and soil of the new land use category was added.

7.3.3 Uncertainties and Time-Series Consistency

The uncertainty for the Key Category 5A1 is 5%for AD. For the EF (CO_2) it is 36% according to the Swiss National Inventory Report (FOEN 2011), see also chapter 1.7 for uncertainty evaluation. The uncertainty of gross growth, cut and mortality is assessed as low. In case of

BEFs, the uncertainty is assessed as medium. In case of soil carbon pool, the uncertainty is assessed as medium (FOEN 2011).

Time series are consistent.

7.3.4 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010).

The LULUCF expert, the NIC and the NIR author report their QC activities in a checklist (see Annex 8).

7.3.5 Source-Specific Recalculations

Only data for the year 2009 has been recalculated:

5A1 has been recalculated due to the correction of an error in the calculation of Carbon stock change in living biomass, dead organic matter and stock change in soils.
5A25 has been recalculated due to the elimination of an error in the activity data (area).

7.3.6 Source-Specific Planned Improvements

No source-specific improvements are planned.

7.4 Source Category 5B – Cropland

7.4.1 Source Category Description

Key source 5B1 Emissions from 5B1 Cropland remaining Cropland are a key source by level. Source category 5B2 “Land converted to Cropland” is not a key source.

11% of Liechtenstein’s total surface is cropland. Land use changes to cropland or from cropland are not very common. The most important changes are from grassland to cropland on the one hand and from cropland to grassland and settlements on the other hand. The total area of cropland decreased by 9.4% between 1990 and 2010.

Croplands in Liechtenstein belong to the cold temperate wet climatic zone. Carbon stocks in aboveground living biomass and carbon stocks in mineral and organic soils are considered. Croplands (CC 21) and include annual crops and leys in arable rotations.

7.4.2 Methodological Issues

7.4.2.1 Cropland remaining Cropland (5B1)

The activity data collection follows the methods described in chapter 7.2.2. Carbon stocks and carbon stock changes are taken from Switzerland. Details are described in the following paragraphs.

a) Carbon in Living Biomass

When cropland remains cropland, the carbon stocks of annual crops are not considered since they are harvested every year. Thus, there is no long-term carbon storage.

b) Carbon in Soils

The Swiss mean soil organic carbon stocks for cropland (53.40 ± 5 t C ha^{-1}) and for cultivated organic soils (240 ± 48 t C ha^{-1}) were applied in Liechtenstein. Both are based on studies from Leifeld et al. (2003) and Leifeld et al. (2005).

c) Changes in Carbon Stocks

Changes in carbon stocks in mineral soil for cropland remaining cropland are due to a loss of 9.52 t C/ha/y.

Carbon stock changes in soil for cropland due to changes from mineral to organic soil are not estimated in Liechtenstein since data on mineral and organic soils is only available for one year. Changes can therefore not be estimated.

d) Carbon Emissions from Agricultural Lime Application

Emissions from lime application are not occurring in Liechtenstein.

7.4.2.2 Land converted to Cropland (5B2)

The activity data collection follows the methods described in chapter 7.2.2.. Carbon factors are displayed in the following paragraphs.

a) Carbon in Living Biomass

When a conversion of a land to cropland occurs, carbon stocks of annual crops are taken into account. This is in line with the Good Practice Guidance LULUCF (IPCC 2003, p. 3.88, table 3.3.8).

The Swiss mean biomass stock for cropland of 5.66 t C ha^{-1} was applied in Liechtenstein. The value is based on area-weighted means of standing stocks at harvest for the seven most important annual crops (wheat, barley, maize, silage maize, sugar beet, fodder beet, potatoes; FOEN 2007).

b) Carbon in Soils

As mentioned under the source category “Cropland remaining cropland” the Swiss mean soil organic carbon stocks for cropland (53.40 ± 5 t C ha^{-1}) and for cultivated organic soils (240 ± 48 t C ha^{-1}) were applied in Liechtenstein.

c) N_2O Emissions from Land Use Conversion to Cropland

N_2O emissions as a result of the disturbance associated with land-use conversion to cropland are reported in CRF Table 5 (III). The emissions are calculated with default values proposed by IPCC (2003, following Equations 3.3.14 and 3.3.15, and Chapter 3.3.2.3.1.2):

Emission (N_2O) = deltaC_s * 1 / (C : N) * EF1 * 44 / 28 [Gg N_2O]

where:

deltaC$_s$: soil carbon difference in soils induced by land-use conversion to cropland [Gg C]

C:N: IPCC default C:N ratio = 15 in forest or grassland soils

EF1: IPCC default emission factor = 0.0125 kg N_2O-N (kg N)$^{-1}$

Where negative emissions would occur (when the deltaC$_s$ is negative), they are set to zero and "NO" is reported in the CRF (e.g. in the year 2008), which is a conservative assumption, as only absorptions are not reported this procedure.

7.4.3 Uncertainties and Time-Series Consistency

The uncertainty for the Key Category 5B1 is 30%for AD. For the EF (CO_2) it is 25% according to the Swiss National Inventory Report (FOEN 2011), see also chapter 1.7 for uncertainty evaluation.

Where available, uncertainties for soil carbon stocks are given together with the mean value in the text. The relative uncertainty in yield determination has been estimated at 13% for biomass carbon from agricultural land (Leifeld et. al. 2005). Data on biomass yields for different elevations and management intensities as published by FAL/RAC (2001) are based on many agricultural field experiments and have a high reliability.

The time-series are consistent.

7.4.4 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010).

The LULUCF expert, the NIC and the NIR author report their QC activities in a checklist (see Annex 8). No additional source-specific QA/QC activities have been carried out.

7.4.5 Source-Specific Recalculations

Only data for the year 2009 has been recalculated:

5B22: The elimination of an error in the activity data (area) lead to minor recalculations.

7.4.6 Source-Specific Planned Improvements

No source-specific improvements are planned.

7.5 Source Category 5C – Grassland

7.5.1 Source Category Description

Key source 5C1 and 5C2
Emissions from 5C1 "Grassland remaining Grassland" are a key source concerning trend.
Source category 5C2 "Land converted to Grassland" is not a key source.

31% of Liechteinstein's total surface is grassland, whereof 85.9% is managed and 14.1% is unmanaged grassland. Conversion to grassland occurs mainly from cropland to grassland and from forest to grassland. These changes are however less important than the reverse conversion from grassland to forest and from grassland to cropland. The total area of grassland decreased by 5.3 % in 2010 compared to 1990.

Liechtenstein's grasslands belong to the cold temperate wet climatic zone. Carbon stocks in living biomass and carbon stocks in soils are considered. Grasslands include permanent grassland (CC 31), shrub vegetation (CC 32), vineyards, low-stem orchards ('Niederstammobst') and tree nurseries (CC 33), copse (CC 34), orchards ('Hochstammobst'; CC 35), stony grassland (CC 36), and unproductive grassland (CC 37). The combination categories CC 31-35 are considered as managed and CC 36-37 as unmanaged grasslands.

7.5.2 Methodological Issues

7.5.2.1 Grassland remaining Grassland (5C1)

The activity data collection follows the methods described in chapter 7.2.2. Carbon stocks are taken from Switzerland. Details are described in the following paragraphs.

a) Carbon in Living Biomass

Permanent Grassland (CC 31)

Permanent grasslands range in altitude from < 300 m to 3000 m above sea level. Because both biomass productivity and soil carbon rely on the prevailing climatic and pedogenic conditions, grassland stocks were calculated separately for three altitude zones (corresponding to those used in source category 5A - Forest Land).

Swiss values for carbon stock in living biomass of permanent grassland are applied (FOEN 2011). The estimation of carbon stocks is based on annual cumulative yield of differentially managed grasslands (FAL/RAC 2001) and on root biomass-C (Ammann et al. 2007). The values for the different altitude zones including roots are displayed in Table 7-26.

Table 7-26 Living biomass Cl of permanent grassland (CC 31).

Altitude [m]	C_l [t C ha^{-1}]
≤ 600	7.45
601-1200	6.26
>1200	4.45

Shrub Vegetation (CC 32) and Copse (CC 34)

Swiss values for living biomass in shrub vegetation and copse were applied (FOEN 2009). Due to a lack of more precise data, the living biomass of shrub vegetation and copse was assumed to correspond with brush forest described in section 7.3.2. Brush forest is assumed to contain 11.6 t C ha^{-1}.

Vineyards, Low-stem Orchards and Tree Nurseries (CC 33)

Swiss values for standing carbon stock of living biomass (Cl) for CC 33 were applied (FOEN 2011). Cl of vineyards is 3.61 t C ha^{-1}, Cl of low-stem orchards is 12.25 t C ha^{-1}. For tree nurseries no stand densities are available. The weighted mean[17] carbon stock of this combination category is 3.74 t C ha^{-1}.

[17] Weighted by the area of orchards and vineyards

Orchards (CC 35)

Orchards are loosely planted larger fruit trees (‘Hochstammobst’) with grass understory. Swiss values for the biomass stock of orchards were applied (FOEN 2011). The total biomass stock of this combination category (including the biomass of the grassland) is assumed to be 24.63 t C ha^{-1}.

Stony Grassland (CC 36)

Stony grassland is categorized as unmanaged grassland. Swiss values for carbon stock of stony grassland were applied (FOEN 2009). The carbon content is assumed to be 4.06 t C ha^{-1}.

Unproductive Grassland (CC 37)

Unproductive grassland is categorized as unmanaged grassland. The category includes grass and herbaceous plants at watersides of lakes and rivers including dams and other flood protection structures, constructions to protect against avalanches and rock slides, and alpine infrastructure. These areas are not used as grassland and are therefore categorised as unmanaged land.

The simple mean value for all altitude classes of grassland of 6.05 t C ha^{-1} is applied, as for none of these land-use types, biomass data are currently available (FOEN 2009).

b) Carbon in Soils

Permanent Grassland (CC 31)

Carbon stocks in grassland soil refer to a depth of 0-30 cm.

Swiss values for carbon stocks in mineral and organic soils are applied (FOEN 2009). They are based on Leifeld et al. (2003) and Leifeld et al. (2005).

The mean carbon stock values for mineral soils are displayed in Table 7-27

Table 7-27 Mean carbon stocks under permanent grassland on mineral soils, ± represents the standard deviation.

Altitude [m]	**C_s** [t C ha^{-1}, 0-30 cm]
≤ 600	62.02 ± 13
601-1200	67.50 ± 12
>1200	75.18 ± 9
Simple mena carbon stock value over altitude classes	*68.23*

The mean soil organic carbon stock (0-30 cm) for organic soils is 240 ± 48 t C ha^{-1}.

Shrub Vegetation (CC 32)

Due to lack of data, the Swiss mean value of carbon stocks under permanent grassland on mineral soils (CC 31) of 68.23 t ha^{-1} was used as the soil carbon default for this category (see Table 7-27) (FOEN 2009).

Vineyards, Low-stem Orchards and Tree Nurseries (CC 33)

Swiss soil carbon values for cropland were applied as it is supposed that these land-use types don't have grass undercover. These soil carbon values are 53.40 t C ha^{-1} for mineral soils and 240 t ha^{-1} for organic soils (FOEN 2009).

Copse (CC 34)

Due to lack of data, the Swiss mean value of carbon stocks under permanent grassland on mineral soils (CC 31) of 68.23 t ha^{-1} was used as the soil carbon default for this category (see Table 7-27) (FOEN 2009).

Orchards (CC 35)

Swiss soil carbon values for grassland from the two lower altitude zones (≤ 1200 m) were taken as no specific orchard values were available. These are 64.76 t C ha^{-1} for mineral soils and 240 t C ha^{-1} for organic soils (FOEN 2009).

Stony Grassland (CC 36)

Swiss values for soil organic carbon under stony grassland were applied. These grasslands are mainly located at altitudes > 1200m a.s.l. A carbon stock Cs of 26.31 t C ha^{-1} is assumed for this combination category (FOEN 2009).

Unproductive Grassland (CC 37)

The category CC 37 ‚unproductive grasslands' includes grass and herbaceous plants at watersides of lakes and rivers including dams and other flood protection structures, constructions to protect against avalanches and rock slides, and alpine infrastructure.

Swiss mean value of carbon stocks under permanent grassland on mineral soils of 68.23 t C ha^{-1} is applied (see Table 7-27), as for none of these land-use types, carbon soil data are currently available (FOEN 2009).

c) Changes in carbon stocks

Changes in carbon stock in mineral soils are due to a loss of 9.52 t C/ha/y for grassland remaining grassland.

Carbon stock changes in soil for grassland due to changes from minearal to organic soil. are not estimated in Liechtenstein since data on mineral and organic soils is only available for one year. Changes can therefore not be estimated.

7.5.2.2 Land converted to Grassland (5C2)

The activity data collection follows the methods described in chapter 7.2.2..

The carbon stocks in living biomass and in soil are reported in detail under "Grassland remaining grassland" and are summarized as follows:

Table 7-28 Summary table of carbon stocks in grassland (CC 31-37)

Combination category	**Carbon in living biomass**	**Carbon in soils**	
		Mineral soils	**Organic soils**
Permanent grassland (CC 31)	4.45-7.45 t C ha $^{-1}$	62.02-75.18 t C ha $^{-1}$	240 t C ha $^{-1}$
Shrub vegetation (CC 32)	11.6 t C ha $^{-1}$	68.23 t C ha $^{-1}$	
Vineyards, low-stem Orchards and Tree Nurseries (CC 33)	3.74 t C ha $^{-1}$	53.4 t C ha $^{-1}$	240 t C ha $^{-1}$
Copse (CC 34)	11.6 t C ha $^{-1}$	68.23 t C ha $^{-1}$	
Orchards (CC 35)	24.63 t C ha $^{-1}$	64.76 t C ha $^{-1}$	240 t C ha $^{-1}$
Stony Grassland (CC 36)	4.06 t C ha $^{-1}$	26.31 t C ha $^{-1}$	
Unproductive Grassland (CC 37)	6.05 t C ha $^{-1}$	68.23 t C ha $^{-1}$	

7.5.3 Uncertainties and Time-Series Consistency

The uncertainty for the Key Category 5C2 is 20% for AD. For the EF (CO_2) it is 50% according to the Swiss National Inventory Report (FOEN 2011), see also chapter 1.7 for uncertainty evaluation.

The relative uncertainty in yield determination has been estimated at 13% for biomass carbon from agricultural land (Leifeld et. al. 2005). Data on biomass yields for different elevations and management intensities as published by FAL/RAC (2001) are based on many agricultural field experiments and have a high reliability.

The time-series are consistent.

7.5.4 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010).

The LULUCF expert, the NIC and the NIR author report their QC activities in a checklist (see Annex 8). No additional source-specific QA/QC activities have been carried out.

7.5.5 Source-Specific Recalculations

Only 2009 data has been recalculated:

5C1 has been recalculated due to an error in the calculation of the Carbon stock change in living biomass.
5C21 and 5C22 are recalculated due to a correction of a calculation error in the total area and in net carbon stock change.
5C25 has been recalculated due to the elimination of an error in the activity data (area).

7.5.6 Source-Specific Planned Improvements

No futher source-specific improvements are planned.

7.6 Source Category 5D – Wetlands

7.6.1 Source Category Description

2.3% of the total surface of Liechtenstein are wetlands. Land-use changes from and to wetlands are not very common and occur mainly from forest land to wetlands (e.g. in case of rivers with flood water). Wetlands consist of surface waters (CC 41) and unproductive wet areas such as shore vegetation and fens (CC 42) (Table 7-3). Both types of wetland are categorized as unmanaged.

7.6.2 Methodological Issues

Source categories 5D1 "Wetlands remaining Wetlands" and 5D2 "Land converted to Wetlands" are not key sources.

7.6.2.1 Wetlands remaining Wetlands (5D1)

The activity data collection follows the methods described in chapter 7.2.2. Carbon stocks are taken from Switzerland. Details are described in the following paragraphs.

a) Carbon in Living Biomass

Surface Waters (CC 41)

Surface waters have no carbon stocks by definition.

Unproductive Wetland (CC 42)

Swiss carbon contents for unproductive wetlands are applied (FOEN 2007). The combination category was stratified according to different tags (e.g. tree group on wetland, biotope, linear tree group on wetland, clear-cut on wetland) and each tag was assigned to a carbon content of a known combination category (e.g. tree group on wetland was assigned to the category unproductive forest). Using the percentages (according to occurrence) and the assigned carbon stock values, a weighted average for this combination category was calculated. This calculation led to an average carbon stock of 7.96 t C ha^{-1}.

b) Carbon in Soils

Land cover in CC 42 includes peatlands and reed. Swiss soil carbon stock values are applied (FOEN 2007). Since only data on peatlands are available (240 t C ha^{-1} as for organic soils), it is suggested that the soil carbon stock of unproductive wetlands is the arithmetic mean of grassland on mineral soils (68.23 t C ha^{-1}) and organic soils (240 t C ha^{-1}), thus 154 t C ha^{-1}.

c) N_2O emissions from drainage of soils

Drainage of intact wetlands is very unlikely. Therefore, no N_2O emissions are reported in CRF Table 5 (II).

7.6.2.2 Land converted to Wetlands (5D2)

The activity data collection follows the methods described in chapter 7.2.2.. In the case of land-use change, the net changes in biomass and soil of both surface waters (CC 41) and unproductive wetland (CC 42) are calculated as described in chapter 7.2.1.

7.6.3 Uncertainties and Time-Series Consistency

The uncertainties for 5D1 and 5D2 are 25% for AD. For the EF (CO_2) it is 50% according to the Swiss National Inventory Report (FOEN 2011), see also chapter 1.7 for uncertainty evaluation.

The time series are consistent.

7.6.4 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010).

The LULUCF expert, the NIC and the NIR author report their QC activities in a checklist (see Annex 8). No additional source-specific QA/QC activities have been carried out.

7.6.5 Source-Specific Recalculations

Only 2009 data has been recalculated:

5D21, 5D22 and 5D23 have been recalculated due to an error in the calculation of the net carbon stock change and total area.
5D25 has been recalculated due to the an error in total area.

7.6.6 Source-Specific Planned Improvements

No source-specific improvements are planned.

7.7 Source Category 5E – Settlements

7.7.1 Source Category Description

Key source 5E2
Emissions from 5E2 “Land converted to Settlements” is a key source by level. Source category 5E1 “Settlements remaining Settlements” is not a key source.

10.8% of Liechtenstein’s total surface are settlements. Between 1990 and 2010, 360 hectares were converted to settlements, which is an increase of 26.4%. Settlements consist of buildings/constructions (CC 51), herbaceous biomass in settlements (CC 52), shrubs in settlements (CC 53) and trees in settlements (CC 54) as shown in Table 7-3.

7.7.2 Methodological Issues

7.7.2.1 Settlements remaining Settlements (5E1)

The activity data collection follows the methods described in chapter 7.2.2. Carbon stocks are taken from Switzerland. As structure and density of Liechtenstein’s settlements are very similar to the settlements in Switzerland, there is no need to collect Liechtenstein specific data on trees in settlements and the Swiss data for CC52, 53 and 54 can be used as they are sufficiently accurate. Details are described in the following paragraphs.

a) Carbon in Living Biomass

Buildings and Constructions (CC 51)

Buildings/constructions contain no carbon by default.

Herbaceous Biomass, Shrubs and Trees in Settlements (CC 52, 53, 54)

Swiss values for carbon stocks of herbaceous biomass, shrubs and trees in settlements are applied (FOEN 2007). The calculation of carbon stock is based on the average crown cover area based annual growth rate (IPCC default value, IPCC 2003; p. 3.297), the percentage of vegetation coverage for the respective combination category (herbaceous biomass or shrubs in settlements) and the estimated average age of trees in settlements (20 years). The combination category “Herbaceous Biomass in Settlement” (CC 52) is estimated to contain an average carbon stock of 5.8 t C ha^{-1}, and the combination category “Shrubs in Settlements” (CC 53) a carbon stock of 4.8 t C ha^{-1}. Due to a lack of data, the carbon content of the combination category “Trees in Settlements” (CC 53) was also used for CC 54 (4.8 t C ha^{-1}).

b) Carbon in Soils

Swiss values for soil carbon in settlements are applied (FOEN 2011).

The carbon stock in soil for the combination category “Buildings and Construction” (CC 51) was set to zero. However, a weighting factor of 0.5 (Leifeld et. al. 2003) was applied to soil carbon changes due to land-use changes involving CC 51 (see Chapter 7.2.1). The reason for this is that in general the soil organic matter on construction sites is stored temporarily and later used for replanting the surroundings or it is used to vegetate dumps for example. The oxidative carbon loss due to the disturbance of the soil structure may reach 50%.

The carbon stock in soil for CC 52, 53 and 54 is 53.40 t C ha^{-1} (0-30 cm, same value as for cropland).

7.7.2.2 Land converted to Settlements (5E2)

The activity data collection follows the methods described in chapter 7.2.2. Carbon factors are reported as described in chapter 7.2.5 for “Settlements remaining Settlements” (CC categories 51-54).

7.7.3 Uncertainties and Time-Series Consistency

The uncertainties for 5E1 and 5E2 are 20% for AD. For the EF (CO_2) it is 50% according to the Swiss National Inventory Report (FOEN 2011), see also chapter 1.7 for uncertainty evaluation.

The time series are consistent.

7.7.4 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010).

The LULUCF expert, the NIC and the NIR author report their QC activities in a checklist (see Annex 8). No additional source-specific QA/QC activities have been carried out.

7.7.5 Source-Specific Recalculations

Only 2009 data has been recalculated:

5E1 has been recalculated due to an error in the carbon stock change in living biomass.

5E21-5E24 have been recalculated due to an error in the calculation of the net carbon stock change and total area.

7.7.6 Source-Specific Planned Improvements

No source-specific improvements are planned.

7.8 Source Category 5F – Other Land

7.8.1 Source Category Description

Source category 5F1 "Other Land remaining Other Land" and source category 5F2 "Land converted to Other Land" are not key sources.

6.4% of Liechtenstein's total surface are summarized in "Other Land". Between 1990 and 2010 the area of "Other Land" has remained rather stable (-0.5%). As shown in Table 7-3 other land (CC 61) covers non-vegetated areas such as glaciers, rocks and shores.

7.8.2 Methodological Issues

By definition, other land has no carbon stocks. In the case of land-use change, the net changes in biomass and soil are calculated as described in chapter 7.2.1.

7.8.3 Uncertainties and Time-Series Consistency

The uncertainties for 5F are 20% for the Activity Data. For the EF (CO_2) it is 50% according to the Swiss National Inventory Report (FOEN 2011), see also chapter 1.7 for uncertainty evaluation.

The time series are consistent

7.8.4 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010).

The LULUCF expert, the NIC and the NIR author report their QC activities in a checklist (see Annex 8). No additional source-specific QA/QC activities have been carried out.

7.8.5 Source-Specific Recalculations

Only 2009 data has been recalculated:

5F22, 5F23, 5F25 have been recalculated due to an error in the calculation of the net carbon stock change and total area.
5F24 has been recalculated due to the correction of an error in total area.

7.8.6 Source-Specific Planned Improvements

No source-specific improvements are planned.

8 Waste

8.1 Overview GHG Emissions

Within the waste sector emissions from four source categories are considered:

- 6A "Solid Waste Disposal on Land"
- 6B "Wastewater Handling"
- 6C "Waste Incineration"
- 6D "Others".

Figure 8-1 depicts Liechtenstein's greenhouse gas emissions in the waste sector between 1990 and 2010 according to the four source categories 6A-D. Additionally Table 8-1 lists the GHG emissions of this sector by gas in CO_2 equivalent (Gg) for the years 1990–2010.

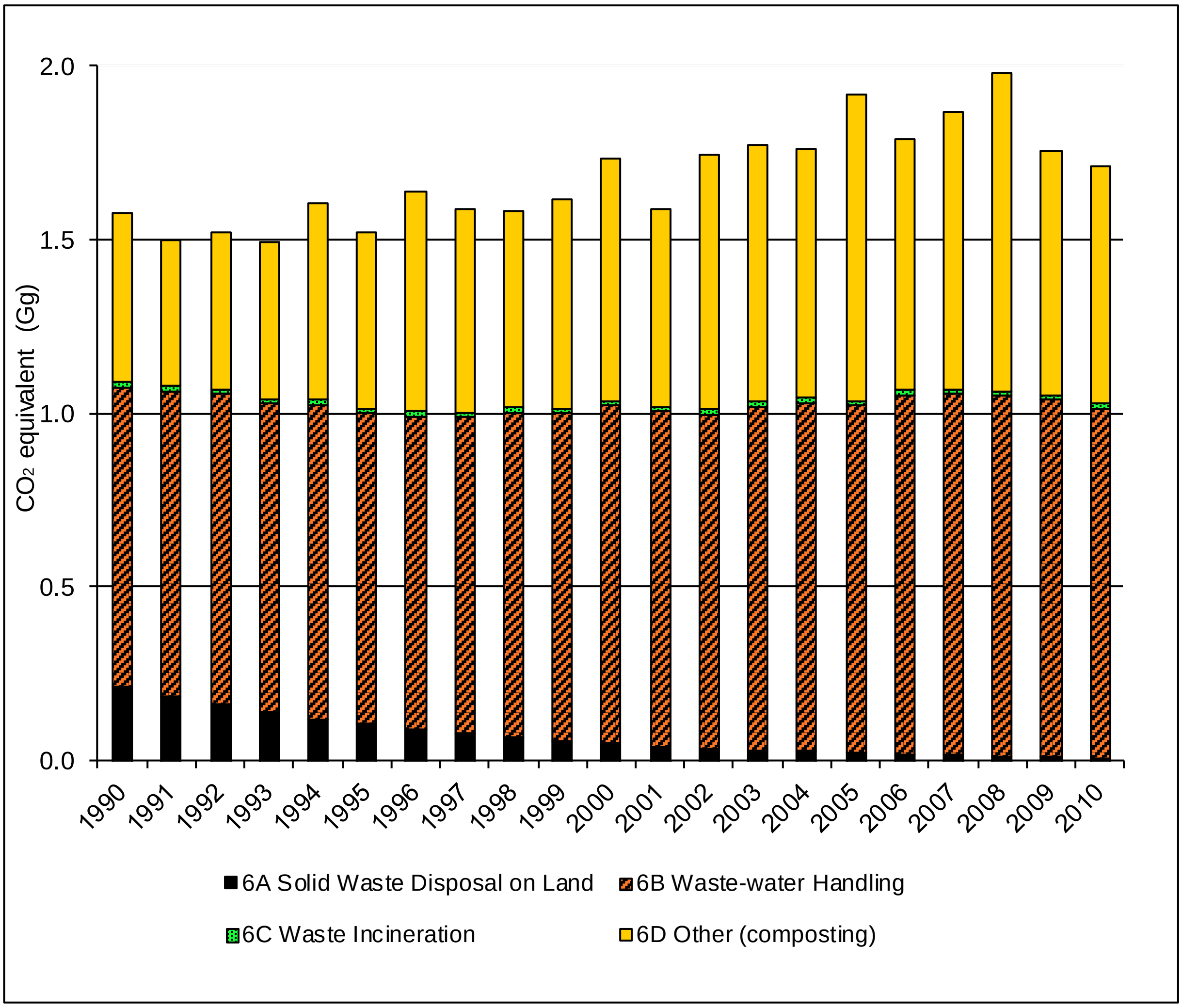


Figure 8-1 Liechtenstein's greenhouse gas emissions in the waste sector 1990–2010.

Table 8-1 GHG emissions of source category 6 Waste by gas in CO_2 equivalent (Gg), 1990–2010.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CO_2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CH_4	0.70	0.62	0.62	0.60	0.68	0.61	0.71	0.66	0.63	0.66
N_2O	0.87	0.87	0.89	0.89	0.91	0.90	0.93	0.92	0.94	0.95
Sum	**1.58**	**1.50**	**1.52**	**1.50**	**1.61**	**1.52**	**1.64**	**1.59**	**1.58**	**1.62**

Gas	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO2 equivalent (Gg)									
CO_2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CH_4	0.74	0.62	0.75	0.75	0.73	0.86	0.73	0.80	0.89	0.71
N_2O	0.99	0.96	0.99	1.02	1.03	1.05	1.05	1.06	1.08	1.04
Sum	**1.74**	**1.59**	**1.75**	**1.77**	**1.76**	**1.92**	**1.79**	**1.87**	**1.98**	**1.76**

Gas	2010	*1990-2010*
	CO2 eq (Gg)	*%*
CO_2	0.01	*8.3*
CH_4	0.69	*-1.5*
N_2O	1.02	*16.5*
Sum	**1.72**	**8.52**

In the waste sector a total of 1.72 Gg CO_2 equivalents of greenhouse gases were emitted in 2010. 0.8% of the total emissions stem from 6A “Solid Waste Disposal on Land”, 58.4% from 6B “Wastewater Treatment”, 0.85% from 6C “Waste Incineration” and 39.98% from the source category 6D “Others” (composting).

The total greenhouse gas emissions show an increase from 1990 until 2010 by +8.5%. This is mostly due to the increase in composting activities in the country (+40.5%).

8.2 Source Category 6A – Solid Waste Disposal on Land

8.2.1 Source Category Description

Source category 6A "Solid Waste Disposal on Land" is **not a key category.**

The source category 6A1 “Managed Waste Disposal on Land” comprises all emissions from handling of solid waste on managed landfill sites.

Liechtenstein has historic unmanaged landfills. During the 1960ies, Liechtenstein stopped disposing of municipal solid waste on landfill sites and instead exported it for incineration to Switzerland. This transition was concluded in 1974, when the last municipality in the country stopped land-filling.

The landfills in Liechtenstein were unmanaged (in the definition of IPCC GPG), because municipal solid waste (MSW) was disposed off on the landfills by users directly (only on 3 of over 30 landfill sites a temporary control by landfill staff was executed). No mechanical compacting or levelling of waste has been carried out. No collection or treatment of leachate took place which caused environmental pollution[18]. Landfills are all less than 5m deep[19].

[18] Source: E-mail Helmut Kindle/OEP of June 24, 2007.

No landfill gas was collected for flaring or energy recovery.

There are no *managed* waste disposal sites reported in Liechtenstein. Therefore emissions from the source category 6A1 “Managed Waste Disposal Sites” are not occurring.

Table 8-2 Specification of source category 6A “Solid Waste Disposal on Land”.

6A1	Managed Waste Disposal on Land	Not occurring in Liechtenstein	-
6A2	Unmanaged Waste Disposal Sites	Emissions from handling of solid waste on unmanaged landfill sites	EF: FOEN 2011 AD: OEP 2007c
6A3	Others	Not occurring in Liechtenstein	-

8.2.2 Methodological Issues

8.2.2.1 Solid Waste Disposal on Unmanaged Waste Disposal Sites (6A2)

8.2.2.2 Methodology

A Tier 2 approach is chosen. The rate of CH_4 generation over time is based on the First Order Decay model (FOD) according to IPCC (IPCC 1997a-c). The following equation is applied to calculate the CH_4 generation in the year t:

$$CH_4 \text{ generated in the year t [Gg/year]} = \sum_x [A \bullet k \bullet M(x) \bullet L_0(x) \bullet e^{-k(t-x)}] \bullet (1-OX)$$

where

t =	current year
x =	the year of waste input, $x \le t$
A =	(1-k)/k, norm factor (fraction)
k =	methane generation rate [1/yr]
M(x) =	the amount of waste disposed in year x
$L_0(x)$ =	methane generation potential ($MCF(x) \bullet DOC(x) \bullet DOC_F \bullet F \bullet 16/12$) [Gg CH_4 / Gg waste]
MCF(x) =	methane correction factor (fraction)
DOC(x) =	degradable organic carbon [Gg C/ Gg waste]
DOC_F =	fraction of DOC, that is converted to landfill gas (fraction)
F =	fraction of CH_4 in landfill gas (fraction)
16/12 =	factor to convert C to CH_4.
OX =	oxidation factor (fraction)

The following general assumptions are made:

MCF(x) = 0.4 = constant for all years (default value according to IPCC for unmanaged solid waste disposal sites of less than 5 m depth)

OX = 0 (default value according to IPCC 1997a-c)

DOC_F = 0.6 (default value according to IPCC 1997a-c)

F = 0.5 (default value according to IPCC 1997a-c)

The degradable organic carbon (DOC) is calculated based on the default values from IPCC 1997a-c and based on country specific data on waste composition for MSW in Switzerland

[19] Source: Email Helmut Kindle/OEP of June 12, 2007, based on research in internal files on old landfills of OEP.

for 1993 (source EMIS 2011 1A1a & 6A1 Kehrichtdeponien). It is assumed that the Swiss MSW composition is representative for the situation in Liechtenstein.

Table 8-3 Calculation of DOC for Liechtenstein (Source DOC: IPCC 1997a-c, source waste fractions: EMIS 2011/1A1a&6A1, Quantities of 1993)

	Waste Fraction	DOC
Paper and Textile and Cardboard %	28	0.4
Garden waste and non-food organic putrescible %	5	0.17
Food waste %	22	0.15
Wood and Straw %	0	0.3
Other materials (glass, metals plastic, minerals, etc.with no contributions to methan generation) %	45	0
Resulting DOC		**0.154**

For the calculation of CH_4 generation from unmanaged landfilling of MSW the k factor is based on FOEN 2011 (Table 8-4). The Swiss NIR assumes a half-life of 5 years, for which k = 0.139 y^{-1} results.

8.2.2.3 Emission Factors

The emissions are directly calculated in the FOD-model as described above and no country specific emission factor was used.

8.2.2.4 Activity data

Activity data for unmanaged MSW Disposal on Land (6A2) have been estimated by OEP (OEP 2007c). The estimates are based on internal (unpublished) research done at OEP from 1985 - 1990 that analysed the development of waste quantities in the last century for the elaboration of a national waste strategy.

Based on this work, the following MSW quantities are assumed to have been landfilled from 1930 until the closure of the last landfill in 1974:

Table 8-4 Amount of MSW landfilled in Liechtenstein (Source: OEP 2007c)

Year	**MSW/cap**	**Inhabitants**	**MSW**
	[kg/a]	(average)	[t/a]
1930-39	150	10500	1575
1940-49	100	12300	1230
1950-59	200	15200	3040
1960-69	300	18500	5550
1970-75	MSW declines linearly to 0		

Because the transition from landfilling in the country to exporting MSW to Switzerland for incineration took place gradually, it is assumed that the amount of MSW landfilled declines linearly after 1970 to zero tons in 1975.

8.2.2.5 Emissions

The following Table 8-5 provides the results of the emission calculation based on the FOD-modeling as well as the waste quantities that have been annually disposed of.

Table 8-5 CH_4 emissions from MSW landfilled in Liechtenstein 1930 – 2012 (Result of FOD model calculation)

Year	Annual Deposition Tons/Year	Emissions t CH_4	Emissions t CO_2 eq
1930	1575	5.0	105.4
1931	1575	9.4	197.2
1932	1575	13.2	277.0
1933	1575	16.5	346.5
1934	1575	19.4	406.9
1935	1575	21.9	459.5
1936	1575	24.1	505.3
1937	1575	26.0	545.1
1938	1575	27.6	579.8
1939	1575	29.0	610.0
1940	1230	29.2	613.2
1941	1230	29.3	615.9
1942	1230	29.4	618.3
1943	1230	29.5	620.4
1944	1230	29.6	622.2
1945	1230	29.7	623.8
1946	1230	29.8	625.2
1947	1230	29.8	626.4
1948	1230	29.9	627.4
1949	1230	29.9	628.3
1950	3040	35.7	750.2
1951	3040	40.8	856.4
1952	3040	45.2	948.7
1953	3040	49.0	1029.1
1954	3040	52.3	1099.0
1955	3040	55.2	1159.8
1956	3040	57.8	1212.8
1957	3040	59.9	1258.9
1958	3040	61.9	1299.0
1959	3040	63.5	1333.9
1960	5550	73.0	1532.2
1961	5550	81.2	1704.9
1962	5550	88.3	1855.1
1963	5550	94.6	1985.8
1964	5550	100.0	2099.6
1965	5550	104.7	2198.6
1966	5550	108.8	2284.7
1967	5550	112.4	2359.7
1968	5550	115.5	2425.0
1969	5550	118.2	2481.7
1970	5550	120.5	2531.1
1971	4440	119.0	2499.8
1972	3330	114.2	2398.3
1973	2220	106.5	2235.7
1974	1110	96.2	2019.8
1975	0	83.7	1757.7
1976	0	72.8	1529.6
1977	0	63.4	1331.1
1978	0	55.2	1158.4
1979	0	48.0	1008.0
1980	0	41.8	877.2
1981	0	36.4	763.4
1982	0	31.6	664.3
1983	0	27.5	578.1
1984	0	24.0	503.1
1985	0	20.8	437.8
1986	0	18.1	381.0
1987	0	15.8	331.5
1988	0	13.7	288.5
1989	0	12.0	251.1
1990	0	10.4	218.5
1991	0	9.1	190.1
1992	0	7.9	165.5
1993	0	6.9	144.0
1994	0	6.0	125.3
1995	0	5.2	109.0
1996	0	4.5	94.9
1997	0	3.9	82.6
1998	0	3.4	71.9
1999	0	3.0	62.5
2000	0	2.6	54.4
2001	0	2.3	47.4
2002	0	2.0	41.2
2003	0	1.7	35.9
2004	0	1.5	31.2
2005	0	1.3	27.2
2006	0	1.1	23.6
2007	0	1.0	20.6
2008	0	0.9	17.9
2009	0	0.7	15.6
2010	0	0.6	13.6
2011	0	0.6	11.8
2012	0	0.5	10.3

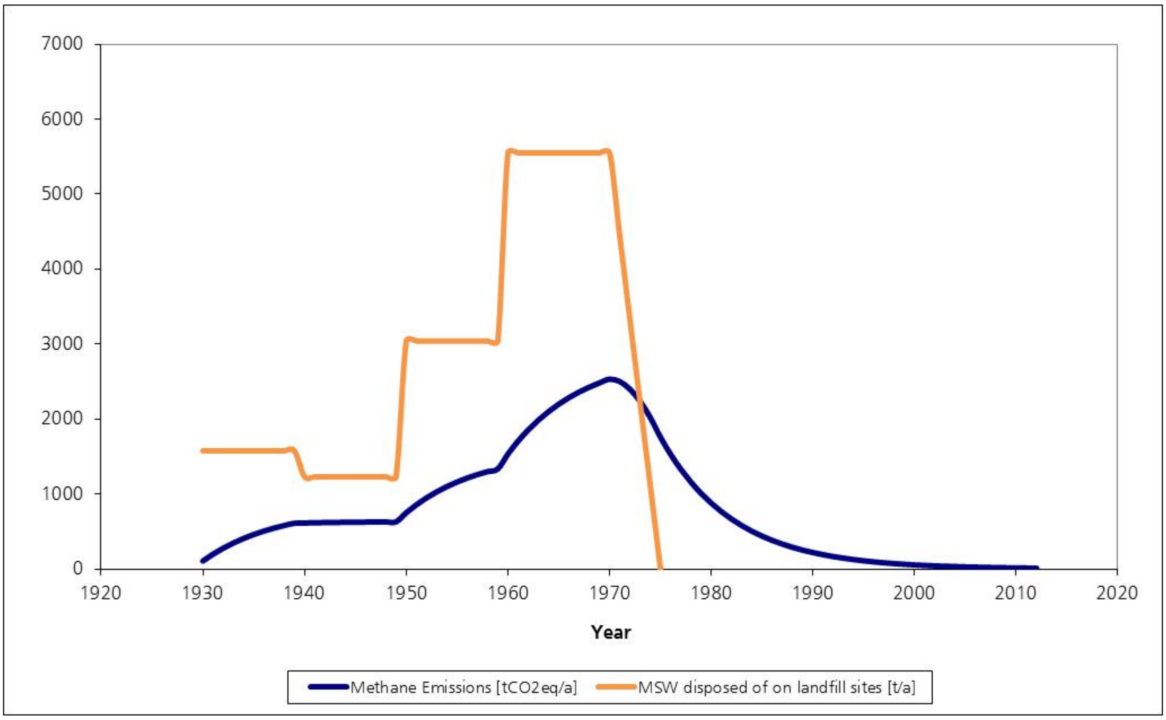


Figure 8-2 MSW disposed of on landfill sites and corresponding emissions of CH_4 in Gg CO_2 equivalents.

8.2.3 Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment based on expert judgment results in low confidence in emission estimates.

The time series is consistent.

8.2.4 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010).

In addition subsequent source-specific activities have been carried out:

- Verification of country specific degradable organic carbon DOC(x) calculations for municipal solid waste, and comparison to the EMIS database 2011 (EMIS 2011 1A1a & 6A1 Kehrichtdeponien).

8.2.5 Source-Specific Recalculations

No recalculations have been carried out.

8.2.6 Source-Specific Planned Improvements

No source-specific improvements are planned.

8.3 Source Category 6B – Wastewater Handling

8.3.1 Source Category Description

Source category 6B “Wastewater Handling” is **not a key source**.

The source category 6B1 “Industrial Waste Water” comprises all emissions from the handling of liquid wastes and sludge from industrial processes such as food processing and metal processing industry[20]. Emissions from source category 6B1 are included in source category 6B2 “Domestic and Commercial Waste Water”. This is motivated by the fact that a higher amount of industrial waste water is pre-treated and not treated on-site, and is then processed in the municipal waste water treatment plants considered under 6B2.

The source category 6B2 “Domestic and Commercial Waste Water” comprises all emissions from handling of liquid wastes and sludge from housing and commercial sources (including gray water and night soil).

Table 8-6 Specification of source category 6B “Wastewater Handling” (AD: activity data; EF: emission factors).

6B	Source	Specification	Data Source
6B1	Industrial Waste Water	Emissions from handling of liquid wastes and sludge from industrial processes. (included in 6B2)	-
6B2	Domestic and Commercial Waste Water	Emissions from handling of liquid wastes and sludge from housing and commercial sources	AD: OEP 2009d (sewage gas production), AZV 2010 (sewage waste quantities) EF: FOEN 2011, IPCC 1997c
6B3	Others	Not occurring in Liechtenstein	-

8.3.2 Methodological Issues

8.3.2.1 Methodology

In Liechtenstein waste water treatment plants are equipped to collect sewage sludge. The sludge is processed in a digester to produce biogas. The biogas is used for co-generation of heat and power on-site.

For CH_4 emissions from domestic and commercial waste water treatment (6B2), a country specific method is used, in line with the method used in the Swiss NIR (FOEN 2011). The CH_4 emissions are calculated by multiplying the amount of biogas produced in the digesters times the emission factor.

N_2O emissions are calculated based on the IPCC default method (IPCC 1997c).

The emissions from the energy generation in the co-generation units itself are reported under 1A1 Energy Industries.

[20] There is one large food producer which pre-treats its effluents that are then further treated in the treatment plant Bendern. It accounts for the major share of industrial waste water. There are however two metal processers which, by now, treat their effluents on-site. As those industrial treatment plants are obsolete, it is planned to conduct a industrial pre-treatment only with a post treatment in Bendern. (According to Egon Hilbe, Amt für Umwelt, LIE, 5.1.2012)

8.3.2.2 Emission Factors

For CH_4 it is assumed that 0.75% of the biogas (volume) is emitted as leakage (SFOE 2002). This value corresponds to the leakage reate used in FOEN 2011 (see in EMIS 2011 6B2 Kommunale Kläranlagen). Based on actual measurements in wastewater treatment plants in Switzerland, a methane content of the biogas by volume of 65% is assumed. With this a country specific emission factor of $0.0049 m^3$ CH_4 per m^3 of biogas results.

N_2O is derived based on the IPCC-default method. For this submission, specific numbers for protein consumption were used. Total protein consumption in Switzerland raised from 237 t in 1990 to 256 t N_2O in 2006 (Swiss Farmer's Union 2006). Values are now available for more recent years. In future submissions is planned to use year specific values for 2007 - 2009 as well. Hence, protein consumption factors range from 34.8 to 32.2 kg/ inhabitant and year. We assume that similar conditions prevail in Liechteinstein. According to previous submissions, an N fraction of 0.16kg N per kg protein (FracNPR; IPCCdefault) was used. Emission factors differ from year to year, and range around 84.9g N_2O per inhabitant[21],

Activity data for CH_4 emissions from Domestic and Commercial Waste Water (6B2) are the total amount of gas resulting from waste water treatment in Liechtenstein. In 1990 three waste water treatment plants had been operational. In 2004, two plants remained, and since 2005 all waste water of the principality is treated in one plant in Bendern.

Table 8-7 Activity data in 6B2 Domestic and Commercial Waste Water: Amount of waste water treatment gas produced by the three treatment plants in Liechtenstein (source: OEP 2009d, AZV 2010).

Gas production		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total gas production	m3	675'944	708'444	750'015	749'887	813'691	736'949	786'301	800'429	866'294	932'935
Balzers	m3	44'256	44'785	42'284	46'055	42'709	43'540	48'964	50'090	48'538	49'206
Vaduz	m3	66'024	55'745	58'464	64'464	64'436	57'713	47'703	0	0	0
Bendern	m3	565'664	607'914	649'267	639'368	706'546	635'696	689'634	750'339	817'756	883'729

Gas production		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total gas production	m3	941'707	905'828	868'172	899'829	939'399	903'804	978'237	1'053'052	1'086'338	1'026'834
Balzers	m3	54'321	53'834	51'144	45'723	5'715	0	0	0	0	0
Vaduz	m3	0	0	0	0	0	0	0	0	0	0
Bendern	m3	887'386	851'994	817'028	854'106	933'684	903'804	978'237	1'053'052	1'086'338	1'026'834

Gas production		2010
Total gas production	m3	965'254
Balzers	m3	0
Vaduz	m3	0
Bendern	m3	965'254

Activity data for N_2O emissions from Domestic and Commercial Waste Water (6B2) are the number of inhabitants (total, i.e. connected and non-connected) in Liechtenstein (provided in Section 4.2.2). Following a technical error, the underlying population numbers 2010 for Liechtenstein are not correct. This error will be addressed by a recalculation in the next submission.

[21] Calculation: 33.86 * 0.16 * 0.01 * 44/28 (According to the molecular weight of N_2O)= 0.0851 kg N_2O per inhabitant.

8.3.3 Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment based on expert judgment results in low confidence in emission estimates.

The time series is consistent.

8.3.4 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010).

In addition, the subsequent source-specific activities have been carried out:

- Verification of N_2O and CH_4 emission factors and comparison to the Swiss NIR 2010 (FOEN 2011).

8.3.5 Source-Specific Recalculations

According to SFOE 2002 for CH_4 it is assumed that 0.75% of the biogas (volume) is emitted as leakage, leading to an overall emission factor of 0.00488 m^3 CH_4 per m^3 of biogas (FOEN 2011). Recalculations were made with the new emission factor for the whole time series.

N_2O emission were recalculated for the whole time series using year-specific values for protein consumption according to the numbers provided by the Swiss Farmer's Union.

8.3.6 Source-Specific Planned Improvements

Following a technical error, in 2010 the underlying population numbers for Liechtenstein as used for 6B2 are not correct. This error will be addressed by a recalculation in the next submission.

Regarding numbers for protein consumption, values for more recent years are available (Swiss Farmer's Union). In future submissions is planned to use year specific values for 2007 -2009 as well.

8.4 Source Category 6C – Waste Incineration

8.4.1 Source Category Description

Source category 6C "Waste Incineration" is **not a key source**.

There are no waste incineration plants in Liechtenstein. Since the beginning of 1975 all municipal solid waste from Liechtenstein is exported to Switzerland for incineration.

Therefore, source category 6C includes only emissions from the illegal incineration of gardening and household wastes, and of wastes on construction sites open burning.

8.4.2 Methodological Issues

8.4.2.1 Methodology

For the calculation of the greenhouse gas emissions from illegal incineration of wastes a country specific Tier 2 method is used, based on CORINAIR, adapted from the Swiss NIR (FOEN 2011).

GHG emissions are calculated by multiplying the estimated amount of illegally incinerated waste by emission factors.

8.4.2.2 Emission Factors

It is assumed that the waste mix in illegal waste incineration is the same as the one for municipal solid waste incineration in Switzerland (FOEN 2011), i.e. 40% of the waste mix is of fossil origin. The main source of fossil CO_2 emissions are plastics.

According to these assumptions, the country specific emission factor for fossil carbon was calculated by multiplying the emission factor for swiss conditions of fossil carbon ((508kg/t) FOEN 2010) by factor 0.4[22], resulting in an EF of 203.2 kg/t. However, the content of 40% fossil origin is already included in the EF adopted from the Swiss NIR. Thus, respective corrections will be made for next submission.

Due to the same incorrect assumptions, the EF of biogenic carbon is underestimated as well. In this case, the EF fossil carbon ((508kg/t) was multiplied by a factor of 0.6, resulting in an EF of 304.8 kg/t biogenic carbon. In the next submission, the specific EF of 706 kg CO2/ t waste for biogenic share of waste as in the Swiss NIR will be adopted.

Country specific emission factors for CH_4 are adopted from the Swiss NIR (FOEN 2011). The country specific emission factor for N_2O is derived from the emission factor for biomass (wood) of 1.6kg N_2O/TJ with a net calorific value for agricultural waste of 12.72GJ/t (FOEN 2010). This is based on the assumption that the waste that is incinerated illegally in gardens, households or on construction sites is composed of a high share of wood.

The following table presents the emission factors used in 6C:

Table 8-8 Emission Factors for 6C "Waste Incineration". CO_2 emission factor relate to both fossil and biogenic carbon.

6C Waste Incineration				
Source	**$CO_{2\ biogen}$** kg/t	**$CO_{2\ fossil}$** kg/t	**CH_4** kg/t	**N_2O** kg/t
Illegal waste incineration	304.8	203.2	6	0.2

8.4.2.3 Activity Data

The activity data for Waste Incineration (6C) are the quantities of waste incinerated illegally. This amount is calculated from the total amount of municipal solid waste generated in Liechtenstein by assuming that waste incinerated illegally represents 0.5% of waste generated[23] (OS 2011c, OEP 2009c). Data for municipal solid waste has been interpolated.

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[22] Source: J. Fuessler, EBP, email to J. Beckbissinger, Acontec, of April 27th, 2007.

[23] This assumption is based on a Swiss study that showed that illegal incineration in private gardens and stoves are of the order of magnitude of 1% of total MSW generation. Assuming that no illegal incineration in gardens takes place in Liechtenstein, a value of 0.5% for illegal incineration in stoves is estimated.

Table 8-9 Activity data for source category 6C "Waste Incineration". Source of amount of municipal solid waste (MSW) generated **OS 2011c**, OEP 2009c.

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
MSW generated	t/a	8'000	8'020	8'040	8'060	8'080	8'100	8'120	8'140	8'160	8'180
Fraction incinerated illegally		0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Waste incinerated illegally	t/a	40.0	40.1	40.2	40.3	40.4	40.5	40.6	40.7	40.8	40.9

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
MSW generated	t/a	8'200	8'220	8'240	8'260	8'280	8'038	8'267	8'338	8'460	8'560
Fraction incinerated illegally		0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Waste incinerated illegally	t/a	41.0	41.1	41.2	41.3	41.4	40.2	41.3	41.7	42.3	42.8

		2010
MSW generated	t/a	8'662
Fraction incinerated illegally		0.5%
Waste incinerated illegally	t/a	43.3

8.4.3 Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment based on expert judgment results in low confidence in emissions estimates.

The time series is consistent.

8.4.4 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010).

In addition to the general QA/QC measures described in Section 1.6 subsequent source-specific activities have been carried out:

- Verification and comparison of emission factors and comparison to the Swiss NIR 2011 (FOEN 2011) and EMIS Database (EMIS 2011 6C2). Results show that the biogenic and fossil CO_2 emission factors differ from both references and will need to be revised for next submission (see section 8.4.6).

8.4.5 Source-Specific Recalculations

In the current version, the amount of waste incinerated is also reported for non-biogenic waste. Hence, CO_2 emissions for biogenic and fossil CO_2 are reported separately.

8.4.6 Source-Specific Planned Improvements

Currently, the emission factor for swiss conditions of fossil carbon is multiplied by the factor 0.4. This is not necessary as the content of 40% fossil origin is already included in the EF. For future submissions the same EF of the Swiss NIR will be adopted for both biogenic and fossil carbon. These improvements are planned for Submission 2013.

8.5 Source Category 6D – Other

8.5.1 Source Category Description

Source category 6D "Other" is **not a key category.**

The source category 6D “Other” comprises the GHG emissions from composting of organic waste. Composting covers the GHG emissions from larger centralized composting plants as well as from backyard composting.

Emissions from the application of compost to agricultural land are reported under category 4 Agriculture.

There are no shredding plants in Liechtenstein, therefore emissions from car shredding are not occurring.

Table 8-10 Specification of source category 6D “Other” (AD: activity data; EF: emission factors).

6D	Source	Specification	Data Source
	Composting	Emissions from composting of organic waste	AD: OS 2011c, OEP 2009c EF: FOEN 2011

8.5.2 Methodological Issues

8.5.2.1 Methodology

For the CH_4 and N_2O emissions from composting a country specific method is used, based on the Swiss NIR (FOEN 2011). The GHG emissions are calculated by multiplying the quantity of wastes by the emission factors. For all years the same constant country specific emission factors have been applied. N_2O emissions from the product of composting that arise after their application in agriculture are reported under source category 4D4.

8.5.2.2 Emission Factors

Emission factors for composting have been adopted from the Swiss NIR (FOEN 2011): 5 kg CH_4/t and 0.07 kg N_2O/t. They are based on measurements and expert estimates, documented in the Swiss EMIS database (EMIS 2011/2A7 and EMIS 2011/6D).

8.5.2.3 Activity data

The Office for Environmental Protection provides data on the amount of waste treated in centralized compost plants. In order to account for the numerous small compost sites in people's backyards, backyard composting has been estimated by an expert estimate[24]: it is estimated to amount to 8% in 1990 and 5% in 2005 and following years compared to the waste composted in centralized compost plants (in the years in between, the factor is linearly interpolated). The expert guess has been re-confirmed by OEP (2012a).

[24] Source: Andreas Gstoehl, OEP, email to J. Beckbissinger, Acontec, of August 16th, 2006.

Table 8-11 Activity data in 6D Other.

Waste composting		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Composted centrally	t/a	3'567	3'078	3'287	3'311	4'143	3'734	4'686	4'316	4'167	4'460
Additionally in backyard		8.0%	7.8%	7.6%	7.4%	7.2%	7.0%	6.8%	6.6%	6.4%	6.2%
Composted total	t/a	3'852	3'318	3'537	3'556	4'441	3'995	5'005	4'601	4'433	4'737

Waste composting		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Composted centrally	t/a	5'210	4'247	5'501	5'508	5'345	6'614	5'442	5'981	6'859	5'258
Additionally in backyard		6.0%	5.8%	5.6%	5.4%	5.2%	5.0%	5.0%	5.0%	5.0%	5.0%
Composted total	t/a	5'522	4'494	5'809	5'806	5'623	6'945	5'714	6'280	7'202	5'521

Waste composting		2010
Composted centrally	t/a	5'154
Additionally in backyard		5.0%
Composted total	t/a	5'411

In 2008, there was a significant increase of composted waste quantities. The peak can be related to the clearing of a forest area in the community of Eschen for environmental restoration[25]. Already in 2009, the total amount of composted material falls back to silimar levels as previous years. The peak is also the reason for the sudden decrease in CH_4 and N_2O emission in 2009 compared to 2008.

8.5.3 Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment based on expert judgment results in low confidence in emissions estimates. The time series is consistent.

8.5.4 Source-Specific QA/QC and Verification

The source-specific QA/QC activities have been carried out as mentioned in sections 1.6.1.4 and 1.6.1.5 including also the triple check of the CRF tables (detailed comparison of latest with previous data for the base year, for 2009 and for the changing rates 2009/2010).

In addition, the subsequent source-specific activities have been carried out:

- Cross check of emission factors in the Swiss NIR (FOEN 2011).

8.5.5 Source-Specific Recalculations

No source-specific recalculations have been carried out.

8.5.6 Source-Specific Planned Improvements

Composting: Liechtenstein reported CH_4 and N_2O emissions from composting. The amount of composting in small compost sites was estimated as a proportion of the amount of composting in centralized compost plants; this estimate was based on expert judgement. The proportion is 8 per cent in 1990 and 5 per cent in 2005. The ERT encourages Liechtenstein to provide more detailed information on the expert judgement in its future inventory submission.

[25] Source: Hr. Bürzle, AfU, oral communication to J. Beckbissinger, acontec, of November 23, 2010

9 Other

9.1 Overview

For submission 2012 the indirect CO_2 emissions due to atmospheric decomposition of NMVOC from source category 3 Solvent and Other Product Use are reported in chapter 9 under source category 7 Other. This is due to a change in reporting in the Swiss National Inventory 2011 which is the basis for Liechtenstein's NIR 2012 for source category 3.

As the changes in the Swiss NIR were not accepted by the reviewers, the emissions will be moved back into chapter 5 in the next year's submission. Therefore, in Liechtenstein's next year's submission the indirect CO_2 emissions will again be reported under source category 3.

This shift has some implications on the total GHG emissions as the CO_2 emissions from source category 7 are not credited for the total amount of emissions and therefore emissions are underestimated. The underestimations are minor and range from 0.47 Gg (2009) to 1.45 Gg (1990).

In Table 9-1 the indirect CO_2 emissions are reported for the years 1990 to 2010.

Table 9-1 Emissions of indirect CO_2 emissions due to atmospheric decomposition of NMVOC

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3											
CO_2	g/inhabitant	14'492	13'970	13'421	12'832	12'168	11'439	10'634	9'780	8'837	8'411

Source	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3											
CO_2	g/inhabitant	7'987	7'539	6'397	5'137	3'772	3'703	3'628	3'548	3'410	3'417

Source	Unit	2010
3		
CO_2	g/inhabitant	3'417

9.1.1 Source-Specific Recalculations

No source-specific recalculations have been carried out for indirect CO_2 emissions from decomposition of NMVOC in the atmosphere but they have been reallocated from NFR Sector 3 to 7 "Other".

Rationale for the reallocation (cited from the Swiss National Inventory 2011 (FOEN 2011)):

"In the workshops on the revision of the reporting guidelines, the discussion over indirect CO_2 emissions was very controversial with an initial disagreement whether the reporting of indirect CO_2 emissions were mandatory today. Furthermore there is a lack of methodological clarity. The 1996 IPCC guidelines as well as the 2000 Good Practice Guidance do not give any methodological detail on the calculation of indirect CO_2 emissions. In the workshop discussion, it was recommended to report indirect CO_2 (and N_2O) emissions separate from total GHG emissions. This recommendation is now reflected in the draft of the revision of the UNFCCC reporting guidelines. In view of this ongoing discussion, Switzerland decided to continue to report the indirect CO_2 emissions on a voluntary basis but to separate the indirect CO_2 emissions (caused by oxidation of NMVOC in the atmosphere) from the direct CO_2 emissions resulting from the burning of NMVOC (e.g. in post-combustion devices installed for air pollution control). The indirect CO_2 emissions are now reported in sector 7 to separate them clearly from the direct emissions/removals which are reported in sectors 1 to 6".

As mentioned before, this rationale was not accepted by the reviewers so the emissions will be moved back to chapter 5 (source category 3) in next year’s submission and the total amount of GHG emission will be corrected.

9.1.2 Source-Specific Planned Improvements

The indirect CO_2 emissions due to atmospheric decomposition of NMVOC from source category 3 Solvent and Other Product Use will be moved back into chapter 5 in next year’s submission.

10 Recalculations

10.1 Explanations and Justifications for Recalculations

The recalculations have been described in the respective subsections of the preceding chapters for all sectors. Furthermore the overview Table 1-1 in Chapter 1.3.3 depicts the issues of the review team that have been incorporated into this new submission.
The recalculations are summarised below.

10.1.1 GHG Inventory

1 Energy
1A3b: 1.A: According to the new Swiss emission factors (FOEN 2011), the implied emission factors for CH_4 and N_2O emissions of the categories 1A3b Road Transportation, 1A4c Other Sectors, Agriculture/Forestry and 1A5b Other/off-road have been updated for the years 1990-2009. The territorial model of road transport in Switzerland has been improved, thus respective methods, activity data and emission factors have also changed for Liechtenstein. However, emission factors for CO_2 remained unchanged. The fleet composition for the years 2004-2009, which in the former model was based on a projection, has been replaced by statistical data. There were no new measurements of CH_4, thus vehicle segment-specific emission factors did not change. Nevertheless, the implied emission factors for CH_4 have changed due to updated composition of the vehicle fleet. The emission factors of N_2O used so far (which were based on Dutch measurement campaign) have been replaced by the emission factors implemented in Coppert 4 model.

2 Industrial Processes

2A5/ 2A6: The number of inhabitants in Liechtenstein has been adjusted for the years 2007, 2008 and 2009 due to new data in (OS 2011c). Preliminary data on the Swiss inhabitants for the year 2009 has been adjusted according to the definite data published in SFOE 2011.

2F1: Due to a technical error, actual emissions from HFC 134a in Sector 2F1 “Refrigeration and Air Conditioning Equipment” have been recalcalculated for the years 2008 and 2009. In submission 2010 and 2011 for these two years activity data from manufacturing were mistakenly reported, although no manufacturing exists in Liechtenstein. This error is now corrected for the submission 2012.

3 Solvent and other Product Use

3A, B, C and D: The number of inhabitants in Liechtenstein has been adjusted for the years 2007, 2008 and 2009 due to adjusted data in (OS 2011c). Preliminary data on the Swiss inhabitants for the year 2009 has been adjusted according to the definite data published in SFOE 2011.

3B: Updated emission factors for metal degreasing and dry cleaning were available for Switzerland. This has led to an updated specific emissions per inhabitant in Switzerland for the years 1990 to 2009 (FOEN 2011). As the specific emissions per inhabitant in Switzerland are used as a proxy for source category 3B, recalculations have been made for the years 1990 to 2009.

4 Agriculture

4A: For 2009, the difference is 0.435 Gg CO_2 eq (+4.2%) compared to Submission 2011. These differences appear mainly due to a major recalculation of Liechtenstein’s methodology and a reassessment of the activity data for young cattle for the whole time series. Basically, activity data coherency was improved in cooperation with Liechtenstein's Office for Agriculture, as different census methodologies were used before 2002 and after (OA 2011b).

Also a recalculation of milk production by mature dairy cattle has been conducted leading to considerably higher values for the years 1999 – 2010. Additionally gross energy intake rates of the young cattle categories "breeding cattle 1st year" (includes breeding calves and breeding cattle 4-12 months) and "fattening cattle" (includes fattening calves 0-4 months and fattening cattle 4-12 months) have been revised, in order to reflect the annual animal husbandry regime more realistically. Both these recalculations contributed to a considerable higher gross energy intake of the total cattle population and hence to higher emission estimates for enteric fermentation than in previous submissions. Furthermore, the energy intake calculation of poultry has been changed using metabolizable energy rather than gross energy as basis for emission factor calculation (according to Hadorn and Wenk 1996) leading to lower values for the whole time series (OA 2011b)

Also, following FCCC/ARR (2010a), "breeding cattle" is now reported the CRF tables under the relevant cattle group an not under "other".

4B: The review questions about the allocation of the nitrogen excreted to the different AWMS (questions Q5, Q8 and Q13, and Para 63 in the FCCC/ARR 2010) have led to an internal review and subsequent revision of the calculation sheets (OEP 2011b). The party has found out that a major recalculation in this sector was necessary, as the total quantity of nitrogen was incorrectly allocated to the different AWMS. Along with this improvement, the recalculated Swiss MCF for deep litter (FOEN 2011) was incorporated.

4D: Liechtenstein's methodology in general has been improved in response to various review questions (e.g. question s Q5, Q8 and Q13, and Para 58 in the FCCC/ARR 2010). With the implementation of these new methodology/calculations-sheets, the consistency between N excretion in 4B and 4D is now guaranteed.
Also the amount of synthetic fertilizer has been recalculated for the whole time series due to recalculations in the amount of synthetic fertilizer in Switzerland in the Submission 2011 (FOEN 2011) for the whole time series.

5 LULUCF

5A: Only data for the year 2009 has been recalculated: 5A1 has been recalculated due to the correction of an error in the calculation of Carbon stock change in living biomass, dead organic matter and stock change in soils.
5A25 has been recalculated due to the elimination of an error in the activity data (area).

5B: Only data for the year 2009 has been recalculated: 5B22: The elimination of an error in the activity data (area) led to minor recalculations.

5C: Only 2009 data has been recalculated:
5C1 has been recalculated due to an error in the calculation of the Carbon stock change in living biomass.
5C21 and 5C22 are recalculated due to a correction of a calculation error in the total area and in net carbon stock change.
5C25 has been recalculated due to the elimination of an error in the activity data (area).

5D: Only 2009 data has been recalculated:

5D21, 5D22 and 5D23 have been recalculated due to an error in the calculation of the net carbon stock change and total area.
5D25 has been recalculated due to the an error in total area.

5E: Only 2009 data has been recalculated:
5E1 has been recalculated due to an error in the carbon stock change in living biomass.

5E21-5E24 have been recalculated due to an error in the calculation of the net carbon stock change and total area.

5F: Only 2009 data has been recalculated:
5F22, 5F23, 5F25 have been recalculated due to an error in the calculation of the net carbon stock change and total area.
5F24 has been recalculated due to the correction of an error in total area.

6 Waste

6B2: Recalculations were made using a new emission factor of 0.00488 m^3 CH_4 per m^3 of biogas for the whole time series. Furthermore, N_2O emission were recalculated for the whole time series using year-specific values for protein consumption according the numbers provided by the Swiss Farmer's Union.

6C: The amount of waste incinerated is now also reported for non-biogenic waste. Hence, CO_2 emissions for biogenic and fossil CO_2 are reported separately.

7 Other

No source-specific recalculations have been carried out for indirect CO_2 emissions from decomposition of NMVOC in the atmosphere but they have been reallocated from NFR Sector 3 to 7 "Other".

Rationale for the reallocation (cited from the Swiss National Inventory 2011 (FOEN 2011)):

"In the workshops on the revision of the reporting guidelines, the discussion over indirect CO_2 emissions was very controversial with an initial disagreement whether the reporting of indirect CO_2 emissions were mandatory today. Furthermore there is a lack of methodological clarity. The 1996 IPCC guidelines as well as the 2000 Good Practice Guidance do not give any methodological detail on the calculation of indirect CO_2 emissions. In the workshop discussion, it was recommended to report indirect CO_2 (and N_2O) emissions separate from total GHG emissions. This recommendation is now reflected in the draft of the revision of the UNFCCC reporting guidelines. In view of this ongoing discussion, Switzerland decided to continue to report the indirect CO_2 emissions on a voluntary basis but to separate the indirect CO_2 emissions (caused by oxidation of NMVOC in the atmosphere) from the direct CO_2 emissions resulting from the burning of NMVOC (e.g. in post-combustion devices installed for air pollution control). The indirect CO_2 emissions are now reported in sector 7 to separate them clearly from the direct emissions/removals which are reported in sectors 1 to 6".

As mentioned before, this rationale was not accepted by the reviewers so the emissions will be moved back to chapter 5 (source category 3) in next year's submission.

10.1.2 KP-LULUCF

No recalculations have been implemented in the KP-LULUCF sector..

10.2 Implications for Emission Levels 1990 and 2008

10.2.1 GHG Inventory

Table 10-1 shows the recalculation results for the base year 1990. The recalculations have the following effect on the emissions in 1990: They decrease the national total emissions by 0.698 Gg CO_2 eq. (0.304%) without emissions/removals from LULUCF. Including LULUCF the decrease is the same, as no recalculations in the LULUCF sector occur.

Table 10-1 Overview of implications of recalculations on 1990 data. Emissions are shown before the recalculation according to the previous submission in 2011 "Prev." (OEP 2011a) and after the recalculation according to the present submission "Latest". The differences "Differ." are defined as latest minus previous submission. Where differences appear, cells are highlighted in grey.

Recalculation	CO_2			CH_4			N_2O			Sum (CO_2, CH_4 and N_2O)		
Emissions for 1990	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)									CO_2 equivalent (Gg)		
1 Energy	201.5	201.5	0.00	1.1	1.1	0.05	0.9	1.1	0.25	203.5	203.8	0.30
2 Ind. Processes (without syn. gases)	NO	NO		NO	NO		NO	NO				
3 Solvent and Other Product Use	1.5	0.1	-1.45				0.5	0.5	0.00	2.0	0.6	-1.45
4 Agriculture				11.7	12.6	0.88	10.9	10.4	-0.51	22.6	23.0	0.37
5 LULUCF	-8.2	-8.2	0.00	NO	NO		NO	NO		-8.2	-8.2	0.00
6 Waste	0.0	0.0	0.00	0.6	0.7	0.05	0.8	0.9	0.02	1.5	1.6	0.08
Sum (without synthetic gases)	194.8	193.4	-1.45	13.4	14.4	0.98	13.1	12.9	-0.24	221.4	220.7	-0.70

Recalculation	**HFC**			**PFC**			**SF6**			**Sum (synthetic gases)**		
Emissions for 1990	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)									CO_2 equivalent (Gg)		
2 Ind. Processes (only syn. gases)	0.00	0.00	0.00	NA,NO	NA,NO		NA,NO	NA,NO		0.0	0.0	0.00

Recalculation		**Sum (all gases)**		
Emissions for 1990		Prev.	Latest	Differ.
Source and Sink Categories		CO_2 equivalent (Gg)		
Total CO_2 eq Em. with LULUCF		**221.35**	**220.66**	**-0.698**
		100.00%	99.68%	-0.315%
Total CO_2 eq Em. without LULUCF		**229.57**	**228.87**	**-0.698**
		100.00%	99.70%	-0.304%

For 2009, the recalculations result in a small decrease of the total emissions in CO_2 equivalents of 0.050 Gg CO_2 eq (-0.035%) without emissions/removals from LULUCF. Including LULUCF the recalculations led to an increase of 0.086 Gg CO_2 eq. (0.021%).

Table 10-2 Overview of implications of recalculations on 2009 data. Emissions are shown before the recalculation according to the previous submission in 2011 "Prev." (OEP 2011a) and after the recalculation according to the present submission "Latest". The differences "Differ." are defined as latest minus previous submission. Where differences appear, cells are highlighted in grey.

Recalculation	CO_2			CH_4			N_2O			Sum (CO_2, CH_4 and N_2O)		
Emissions for 2009	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)									CO_2 equivalent (Gg)		
1 Energy	213	213	0.00	1.9	1.9	0.04	1.0	1.0	-0.05	216.3	216.3	-0.01
2 Ind. Processes (without syn. gases)	NO	NO		NO	NO		NO	NO				
3 Solvent and Other Product Use	0.7	0.3	-0.47				0.3	0.3	0.003	1.0	0.5	-0.47
4 Agriculture				12.14	12.92	0.78	10.7	10.3	-0.42	22.8	23.2	0.35
5 LULUCF	-6.1	-6.0	0.13	NO	NO		0.0	0.0	0.00	-6.1	-6.0	0.14
6 Waste	0.01	0.01	0.00	0.6	0.7	0.08	1.1	1.0	-0.03	1.7	1.8	0.05
Sum (without synthetic gases)	208	208	-0.34	14.7	15.6	0.89	13.1	12.6	-0.50	235.7	235.8	0.06

Recalculation	**HFC**			**PFC**			**SF6**			**Sum (synthetic gases)**		
Emissions for 2009	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)									CO_2 equivalent (Gg)		
2 Ind. Processes (only syn. gases)	5.34	5.33	-0.01	0.1	0.05	0.00	0.14	0.14	0.00	5.53	5.53	-0.01

Recalculation		**Sum (all gases)**		
Emissions for 2009		Prev.	Latest	Differ.
Source and Sink Categories		CO_2 equivalent (Gg)		
Total CO_2 eq Em. with LULUCF		**241.25**	**241.30**	**0.050**
		100.00%	100.02%	0.021%
Total CO_2 eq Em. without LULUCF		**247.40**	**247.32**	**-0.086**
		100.00%	99.97%	-0.035%

10.2.2 KP-LULUCF

Table 10-3 shows that no recalculations take place in the KP-LULUCF tables on emissions/removals from KP-LULUCF in 2009. Also for 2008 no reacalcuations were executed.

Table 10-3 Overview of implications of recalculations on 2009 data. Emissions are shown before the recalculation according to the previous submission in 2011 "Prev." (OEP 2011a) and after the recalculation according to the present submission "Latest".

Recalculation of KP-LULUCF Art. 3.3. activities			
Emissions for 2009	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)		
A.1.1 Afforestation& Reforestation	-3.22	-3.22	0.00
A.2 Deforestation	0.43	0.43	0.00
Total CO_2 eq emission/removal from KP-LULUCF	**-2.79**	**-2.79**	**0.00**

10.3 Implications for Emissions Trends, including Time Series Consistency

10.3.1 GHG Inventory

Due to recalculations, the emission trend 1990–2009 reported in the 2011 submission has marginally changed. Compared to 1990, 2009 emissions (national total without emissions/-removals from LULUCF) showed an increase of 7.77% before recalculation (previous submission). After recalculation, the increase turns out to be slightly higher: 8.06% (latest submission).

Table 10-4 Change of the emission trend 1990–2009 due to recalculations.

Recalculation	**1990**		**2009**		**change 1990/2009**	
Submission	previous	latest	previous	latest	previous	latest
	CO_2 eq (Gg)				%	
Total excl. LULUCF	229.57	228.87	247.40	247.32	7.77%	8.06%

All time series in the present submission are consistent.

10.3.2 KP-LULUCF

No recalculations and thus no changes in emissions trends for KP-LULUCF

10.4 Recalculations in Response to the Review Process and Planned Improvements

10.4.1 GHG Inventory

See Chapter 10.1.1 and Chapter 1.3.3, Table 1-1 Incorporated issues according to ERT recommendations from FCCC/ARR 2010 and FCCC/ARR 2010a.

10.4.2 KP-LULUCF

See Chapter 1.1.1

Part 2
Supplementary Information Required under Article 7, Paragraph 1

11 KP – LULUCF

11.1 General Information

The information in this chapter is provided in accordance with Decision 15/CP.10 (FCCC/CP/2004/10/Add.2) and based on the information given in Liechtenstein's Initial Report (OEP 2006a) and the Corrigendum to the Initial Report of 19 Sep 2007 (OEP 2007b).

Liechtenstein has chosen to account annually for emissions and removals from the KP-LULUCF sector (see Chapter 7 of the Initial Report OEP 2006a).The decision remains fixed for the entire first commitment period. Liechtenstein submits data for the third mandatory submission year 2010 in this submission.

Table 11-1 shows the activity coverage and the pools reported for the activities under Article 3, paragraph 3 and Forest Management under paragraph 4 of the Kyoto Protocol for 2010. The Area change between the previous and the current inventory year is shown in Table 11-2.

Table 11-1 The table contains information of country specific activities under Article 3.3 (KP(LULUCF) NIR 1)

TABLE NIR 1. SUMMARY TABLE
Activity coverage and other information relating to activities under Article 3.3 and elected activities under Article 3.4

Activity		Change in carbon pool reported[1]					Greenhouse gas sources reported[2]						
		Above-ground biomass	Below-ground biomass	Litter	Dead wood	Soil	Fertilization[3]	Drainage of soils under forest management	Disturbance associated with land-use conversion to croplands	Liming	Biomass burning[4]		
							N_2O	N_2O	N_2O	CO_2	CO_2	CH_4	N_2O
Article 3.3 activities	Afforestation and Reforestation	R	IE	NR	NR	R	NO			NO	NO	NO	NO
	Deforestation	R	IE	R	R	R			NO	NO	NO	NO	NO
Article 3.4 activities	Forest Management	NA	NA	NA	NA	NA	NA	NA		NA	NA	NA	NA
	Cropland Management	NA	NA	NA	NA	NA			NA	NA	NA	NA	NA
	Grazing Land Management	NA	NA	NA	NA	NA				NA	NA	NA	NA
	Revegetation	NA	NA	NA	NA	NA				NA	NA	NA	NA

(1) Indicate R (reported), NR (not reported), IE (included elsewhere) or NO (not occurring), for each relevant activity under Article 3.3 or elected activity under Article 3.4. If changes in a carbon pool are not reported, it must be demonstrated in the NIR that this pool is not a net source of greenhouse gases. Indicate NA (not applicable) for each activity that is not elected under Article 3.4. Explanation about the use of notation keys should be provided in the text.

(2) Indicate R (reported), NE (not estimated), IE (included elsewhere) or NO (not occurring) for greenhouse gas sources reported, for each relevant activity under Article 3.3 or elected activity under Article 3.4. Indicate NA (not applicable) for each activity that is not elected under Article 3.4. Explanation about the use of notation keys should be provided in the text.

(3) N_2O emissions from fertilization for Cropland Management, Grazing Land Management and Revegetation should be reported in the Agriculture sector. If a Party is not able to separate fertilizer applied to Forest Land from Agriculture, it may report all N_2O emissions from fertilization in the Agriculture sector.

(4) If CO_2 emissions from biomass burning are not already included under changes in carbon stocks, they should be reported under biomass burning; this also includes the carbon component of CH_4. Parties that include CO_2 emissions from biomass burning in their carbon stock change estimates should report IE (included elsewhere).

Table 11-2 KP(LULUCF) NIR 2 - Land Transition Matrix.

Table NIR 2. LAND TRANSITION MATRIX

Areas and changes in areas between the previous and the current inventory year (1), (2), (3)

From previous inventory year \ To current inventory year		Article 3.3 activities: Afforestation and Reforestation	Article 3.3 activities: Deforestation	Article 3.4 activities: Forest Management (if elected)	Article 3.4 activities: Cropland Management (if elected)	Article 3.4 activities: Grazing Land Management (if elected)	Article 3.4 activities: Revegetation (if elected)	Other (5)	Total area at the beginning of the current inventory year(6)
		(kha)							
Article 3.3 activities	Afforestation and Reforestation	0.61	NO						0.61
	Deforestation		0.02						0.02
Article 3.4 activities	Forest Management (if elected)		NO	NA					NA,NO
	Cropland Management(4) (if elected)	NA	NA		NA	NA	NA		NA
	Grazing Land Management(4) (if elected)	NA	NA		NA	NA	NA		NA
	Revegetation(4) (if elected)	NA			NA	NA	NA		NA
Other (5)		0.01	NA	NA	NA	NA	NA	NA	0.01
Total area at the end of the current inventory year		0.62	0.02	NA	NA	NA	NA	NA	0.64

(1) This table should be used to report land area and changes in land area subject to the various activities in the inventory year. For each activity it should be used to report area change between the previous year and the current inventory year. For example, the total area of land subject to Forest Management in the year preceding the inventory year, and which was deforested in the inventory year, should be reported in the cell in column of Deforestation and in the row of Forest Management.

(2) Some of the transitions in the matrix are not possible and the cells concerned have been shaded.

(3) In accordance with section 4.2.3.2 of the IPCC good practice guidance for LULUCF, the value of the reported area subject to the various activities under Article 3.3 and 3.4 for the inventory year should be that on 31 December of that year.

(4) Lands subject to Cropland Management, Grazing Land Management or Revegetation which, after 2008, are subject to activities other than those under Article 3.3 and 3.4, should still be tracked and reported under Cropland Management, Grazing Land Management or Revegetation, respectively.

(5) "Other" includes the total area of the country that has not been reported under an Article 3.3 or an elected Article 3.4 activity.

(6) The value in the cell of row "Total area at the end of the current inventory year" corresponds to the total land area of a country and is constant for all years.

Table 11-3 KP(LULUCF) NIR 3 – Key Categories.

TABLE NIR 3. SUMMARY OVERVIEW FOR KEY CATEGORIES FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL

KEY CATEGORIES OF EMISSIONS AND REMOVALS	GAS	CRITERIA USED FOR KEY CATEGORY IDENTIFICATION			COMMENTS [3]
		Associated category in UNFCCC inventory[1] is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory [1], [4] (including LULUCF)	Other [2]	
Specify key categories according to the national level of disaggregation used[1]					
Forest Management	CO2	Forest land remaining forest land	Yes	Quantitative criteria for key	Level and Trend Assessment following IPCC 1997 and IPCC LULUCF GPG 2003.
Afforestation and Reforestation	CO2	Conversion to forest land	Yes	Quantitative criteria for key	Level and Trend Assessment following IPCC 1997 and IPCC LULUCF GPG 2003.
Deforestation	CO2	Conversion to grassland	No	Quantitative criteria for key	Level and Trend Assessment following IPCC 1997 and IPCC LULUCF GPG 2003.

(1) See section 5.4 of the IPCC good practice guidance for LULUCF.
(2) This should include qualitative consideration as per section 5.4.3 of the IPCC good practice guidance for LULUCF or any other criteria.
(3) Describe the criteria identifying the category as key.
(4) If the emissions or removals of the category exceed the emissions of the smallest category identified as key in the UNFCCC inventory (including LULUCF), Parties should indicate YES. If not, Parties should indicate NO.

An overview of net CO_2 equivalent emissions and removals of activites under Article 3, paragraph 3 in 2010 is shown in Figure 11-1 and Table 11-4.

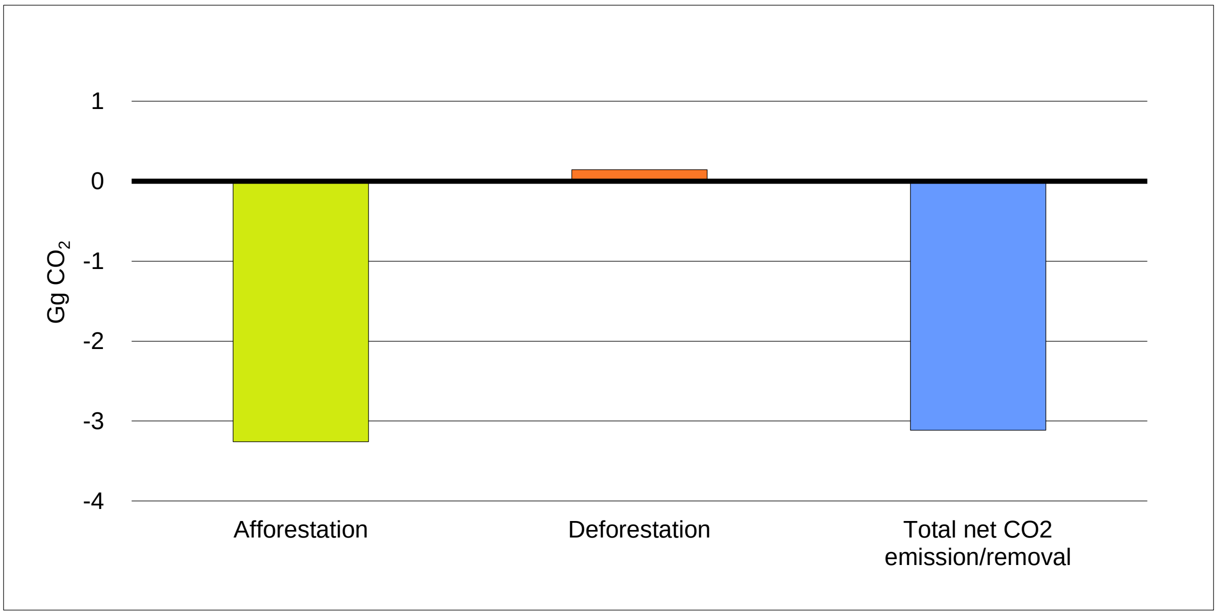

Figure 11-1 Emissions (positive sign) and removals (negative sign) from Afforestation and Deforestation under Article 3, paragraph 3 and the total contribution of these activities in Gg CO_2 for 2010.

Table 11-4 Overview on net CO_2 equivalent emissions (positive sign) and removals (negative sign) for activities under Article 3, paragraph 3 of the Kyoto Protocol in 2010.

Activity	Area (cumulated 1990-2010) kha	Net CO_2 emisson/removal 2010 Gg CO_2
Afforestation	0.61	-3.26
Deforestation	0.02	0.14
Total net CO_2 emission/removal		**-3.11**

The afforested area caused removals of -3.26 Gg CO_2 in 2010. As there was no deforestation occurring in 2010, only little CO_2 (0.14 Gg) was emitted through the soils in areas deforested before 2010. Therefore a net removal of -3.11 Gg CO_2 in 2010 is resulting.

11.1.1 Definition of Forest and any other Criteria

11.1.1.1 Definition of Forest

For activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol, the Marrakech Accords (in the annex to decision 16/CMP.1) list the definitions to be specified by Parties. Liechtenstein's definitions for Forest, Afforestation and Deforestation are specified in the corrigendum to Liechtenstein's Initial Report (OEP 2007b, see there in Chapter 4) and summarized below. Liechtenstein applies the forest definition of the Swiss Land Use Statistics (AREA) of the Swiss Federal Statistical Office. AREA provides an excellent data base to derive accurate, detailed information of not only forest areas, but all types of land use and land cover. Thus, AREA offers a comprehensive, consistent and high quality data set to estimate the surface area of the different land use categories in reporting under the Kyoto Protocol. For Liechtenstein, the Land Use Statistics has been built up identically to Switzerland (same method and data structures, same realisation)

- minimum area of land: 0.0625 hectares (with a minimum width of 25 m)
- minimum crown cover: 20 per cent
- minimum height of the dominant trees: 3 m (dominant trees must have the potential to reach 3 m at maturity in situ)

In Liechtenstein's Initial Report, the following precisions are stated (OEP 2006a, p.20f.):

The following forest areas are not subject to the criterion of minimum stand height: shrub forest consisting of dwarf pine (Pinus mugo prostrata) and alpine alder (Alnus viridis).

The following forest areas are not subject of the criteria of minimum stand height **and** minimum crown cover, but must have the potential to achieve both criteria:

a) afforested area on land not under forest cover for 50 years (afforestations);
b) regenerated forest, as well as burned, cut or damaged areas situated on land classified as forest.

Although orchards, parks, camping grounds, open tree formations in settlements, gardens, cemeteries, sports and parking fields may fulfil the (quantitative) forest definition, they are not considered as forests.

The definitions given below refer exclusively to **directly human-induced** activities:

11.1.1.2 Afforestation

Definition: Afforestation is the conversion to forest of an area not fulfilling the definition of forest for a period of at least 50 years if
(a) the definition of forest in terms of minimum area (625 m^2) is fulfilled, and
(b) the conversion is a direct human-induced activity.

Natural forest regeneration due to abandonment of agricultural land use land is not considered to be a direct human-induced activity.

The area of forest land reported for Afforestation under the Kyoto Protocol is equal to the area reported for Land use changes to forests (see Chapter 7.3.2.2). Afforestations in Liechtenstein are identified

- by aerial photographs which form the basis of Liechtenstein's Land-Use Statistics. In afforestations, the trees are planted in regular patterns, which may easily be recognised in the identification process. This procedure is carried out for all afforestations that happened before 2002 where the latest land-use photographs were taken.
- The afforestations which are identified by aerial photographs by method referred to above are compared with the administrative registers on afforestations endorsed by the Office of Forest, Nature and Landscape since 1990. Through this cross check the consistency of the two data sources are verified.
- Afforestations in the period after 2003 will be identified referring to the administrative registers on afforestations endorsed by the Office of Forest, Nature and Landscape. Since afforestations need legal authorisation (Art. 12 and Art 24 of Forest Law), every afforestation is documented in a proper project containing information on geographic location, area, appointed time etc. Since subsidies are granted for afforestations, they are also documented in the national finances. After being afforested, an area is also legally characterised as forest.
- To ensure that the total area of forest does not decrease (Forest law Art. 1), areas affected by direct human-induced activities have to be compensated (Forest law Art. 7), mainly by afforestation of the same spatial extent. Natural forest regeneration due to higher temperatures (rising of timberline) or the abandonment of agricultural land use, mainly occurring in the Alpine area, is not counted as afforestation and is therefore not counted under Article 3, paragraph 3 of the Kyoto Protocol.

Afforestations since 1990 were not subject to harvesting or clear cutting, since there are no forests with such short rotation lengths. For reporting under the Kyoto Protocol, afforested areas always remain in the "afforestation" category. Therefore, the area of afforestations is increasing since 1990.

11.1.1.3 Deforestation

Definition: Deforestation is the permanent conversion of areas fulfilling the definition of forest in terms of minimum forest area (625 m^2) to areas not fulfilling the definition of forest as a consequence of direct human influence.

Deforestation is prohibited by the National Law on Forests with article 6 (Government 1991). Exceptions need governmental authorisation. The authorisation documents are collected by the Office of Forest, Nature and Landscape (OFNLM) and are annually reported to the Parliament. To ensure that the total area of forest does not decrease, areas affected by direct human-induced deforestation have to be compensated, mainly by afforestation of the same spatial extent but not at the same location. Natural forest regeneration due to abandonment of land, mainly occurring in the Alpine area, is not counted as afforestation and is therefore not counted under Article 3, paragraph 3 of the Kyoto Protocol.

In Liechtenstein, human-induced deforestation is subject to authorisation as mentioned above. Authorisations include the obligation to regenerate the forest area within a few years as part of substitute measures in other areas. Nevertheless such land-use change is classified as permanent deforestation and accordingly accounted for under Article 3, paragraph 3 of the Kyoto Protocol.

The area of forest land reported for Deforestation under the Kyoto Protocol is equal to the sum of deforested areas each with a minimal extension of 625 m^2 and for which authorisation has been granted by the Government of Liechtenstein (that means that deforestations with an area smaller than 625 m^2 are not reported under the Kyoto Protocol). Every single authorisation is documented including information on area as well as schedule and maps in the “Rodungsstatistik” (see Table 11-5).

The area reported for KP-LULUCF differs from the area of deforested land reported in the UNFCCC greenhouse gas inventory (chpts. 7.2.2 and 7.2.4) due to the required distinction in the KP-LULUCF Inventory between human-induced deforestation and not human-induced deforestation.

11.1.1.4 Reforestation

Reforestation does not occur in Liechtenstein (see Sect. 11.4.1).

11.1.1.5 Information used for completing Kyoto tables

The spatial assessment unit for the submission of the Kyoto Protocol LULUCF tables 2011 covers the entire territory of Liechtenstein.

Since all forests in Liechtenstein are subject to forest management, the area of managed forest corresponds to the forest area derived from the Liechtenstein’s Land Use Statistics (EDI/BFS 2009).

11.1.2 Elected Activities under Article 3, paragraph 4, of the Kyoto Protocol

Liechtenstein has elected to not account for LULUCF activities under Article 3.4 during the first commitment period[26], as stated in its Initial Report (OEP 2006b, p.22).

11.1.3 Description of how the definitions of each activity under Article 3.3 have been implemented and applied consistently over time

See Chapter 11.1.1.1. All time-series are consistent

[26] Regierung des Fürstentums Liechtenstein: Kyoto-Protokoll – Initial Report – Anrechnung von Senken, RA 2006/2168-8642, Vaduz, 05.09.2006

11.1.4 Precedence Conditions / Hierarchy, Determination among Article 3.4. activities

Liechtenstein has decided not to account for activities under Article. 3.4.

11.2 Land-related Information

11.2.1 Spatial Assessment Unit used for determining the Area of the units of Land

The spatial assessment unit for the submission of the KP LULUCF tables 2011 covers the entire territory of Liechtenstein.

11.2.2 Methodology used to develop the Land transition Matrix

The methodology used to develop the land transition matrix is described in detail in Chapter 7.2.4.

11.2.3 Maps / Database to identify the geographical Locations and the system of identification Codes for the geographical Locations

See Chapter 11.1.1.1 and also Figure 7-3, Table 7-3 and Table 7-4 in Chapter 7.2.

11.3 Activity-specific Information

11.3.1 Methods for Carbon Stock Change and GHG Emission and Removal estimates

11.3.1.1 Description of the Methodologies and the underlying Assumptions used

See Chapter 7.2.5 and the relevant subchapters of each Source Category 7.x.2. Methodological Issues.

Afforestations

In Liechtenstein, afforestations mostly occur on grasslands (CC31-34 in Table 7-8).

Gross growth of living biomass (carbon stock change in above ground biomass) was calculated with the carbon stock change factors for CC31 (Table 7-8) minus the carbon stock change factor for CC11 over 20 years.

Yearly changes in soil carbon are based on the difference in carbon stocks between permanent grasslands CC 31 and afforestated forests CC11 for the three altitude zones and the soil type mineral soil. The resulting increase in soil carbon was evenly distributed over the IPCC default conversion time of 20 years, giving an evenly distributed yearly change in soil carbon stock to move from the soil carbon stock level of grasslands to the level of productive forests.

Deforestations

Change in total carbon stock of living biomass, litter and dead wood is modelled by using the the deforested area in 2009 (see Table 11-5) and carbon stock change factors from Table 7-8 (CC12), as they are immediately removed after deforestation. In contrary soil carbon pool of the whole deforested area since 1990 (Covington 1981, Rusch et. al. 2009) is reduced by 50% over a conversion period of 20 years.

11.3.1.2 Justification when omitting any Carbon Pool or GHG Emissions/Removals from Activities

KP-LULUCF Table NIR 1 (see Table 11-2) summarizes the activity coverage and the pools reported.

When using the conservative Tier 1 approach (IPCC 2003, Sect. 3.1.5) assuming a specific carbon pool to be in carbon balance, the carbon pool is indicated as reported (R).

The pool "above ground biomass" always reflects the total living biomass as "below-ground biomass" is included in the above ground biomass pool which was calculated by applying the BEF factor (see Chapter 7.3.2.1). The BEF includes the total biomass of the wood pool as described in Thürig et. al (2005). Round wood over bark was expanded to total biomass by applying allometric single tree functions to all trees measured. Correspondingly "included elsewhere" (IE) is set in the KP- LULUCF table. This methodology is in line with the Swiss methodology which underwent in-country review in 2010 and was approved to be in line with the guidelines.

On Grasslands there is no litter and no dead wood and mostly a lower carbon stock level than in forests. Because an increase of carbon in these pools is expected after a conversion from grasslands to forests (afforestations) (compare Table 7-8 of the NIR) a Tier 1 approach has been considered in terms of IPCC good practice (IPCC 2003, Sect. 3.1.5) and no changes (NR) in the litter and dead wood pools for afforestations has been reported.

Fertilisation, drainage of soils, disturbance associated with land-use conversion to croplands, liming and biomass burning are nor occurring (NO)

Thus, for Liechtenstein only the two lines (rows) with „Articles 3.3 activities" apply (Table 11-2).

11.3.1.3 Information on whether or not indirect and natural GHG Emissions and Removals have been factored out

No anthropogenic greenhouse gas emissions and removals resulting from LULUCF activities under Article 3, paragraph 3 and 4 have been factored out.

11.3.1.4 Changes in Data and Methods since the previous Submission (Recalculations)

No recalculations have been carried out since the KP-LULUCF Inventory of the submission 2011 (OEP 2011a) of the Saturday Paper (OEP 2010c):

11.3.1.5 Uncertainty Estimates

A quantitative uncertainty analysis has been carried out for the KP-LULUCF sector for the first time. **The combined level uncertainty for KP-LULUCF is estimated to be 24.6%. Thus, with a probability of 95%, the KP-LULUCF sink lies between 2.35 and 3.88 Gg CO_2 .**

The detailed uncertainties for afforestation and deforestation are estimated as follows:

Afforestation:

AD uncertainty is 20% and EF uncertainty is 36% according to Table 1-7. 5A2 "Land converted to Forest Land". Thus combined total uncertainty for afforestation is 26.6%.

Deforestation:

AD uncertainty is estimated to be 1% due to the very exact data on deforestations in Liechtenstein (Rodungsstatistik), where every single deforestation has to be authorised.

EF uncertainty of 50% is taken from the uncertainty estimate for 5E2 "Land converted to settlements" (see Table 1-7) as this is the main reason for conversion of forest land.

Combined total uncertainty for deforestation is 44.7%.

11.3.1.6 Other methodological Issues

Time series are consistent.

11.4 Article 3.3.

Table NIR 1

Table NIR 1 (see Table 11-1) of the KP-LULUCF Inventory lists all the relevant Article 3.3 data.

Table NIR 2

The change in area between the Activities under Article 3, paragraph 3 between the base and current inventory year is listed in Table 11-2 (Table NIR 2). For Liechtenstein, only columns with „Articles 3.3 activities“ apply. Area changes from afforestation to deforestation did not occur with the period 1990-2010 as explained above in Chpt 11.1.1.1.

Table NIR 3

The table summarizes information on key categories (Table 11-3). See comments in Sect. 11.6.1.

Further Kyoto tables 5(KP)A

- 5(KP-I)A.1.1 Afforestation: Change in carbon stock is modelled by using the cumulated area of afforested land over the whole period (the sum of CC11 of all the three strata over the respective period, see Table 7-6) as explained in Chapter 11.1.1.2 Carbon stock change factors for CC11 are listed in Table 7-8.
- 5(KP-I)A.1.2 Afforestation: there are no units of land afforested later than 1990 and harvested subsequently.
- 5(KP-I)A.2 Deforestation: Change in total carbon stock of living biomass, litter and dead wood is modelled by using the deforested area of the respective year and carbon stock change factors from Table 7-8 (CC12). In Deforestation, all the carbon in living biomass, dead wood and litter is immediately removed in the same year of deforestation. Note that unlike the activity data used, in the overview table NIR-2 of the KP-LULUCF tables the cumulated area of deforested land over the whole commitment period is reported. In contrary, calculation of carbon stock change in soils is based on the whole deforested area since 1990, as soil carbon pool is reduced by 50% over a conversion period of 20 years.

The contribution of Afforestations and Deforestations in terms of CO_2-equivalents is considerably different (Figure 11-1). Since carbon from living biomass is immediately removed after clear-cutting, Deforestations can be considered as a “quick carbon-loosing process” (except for soil carbon). In contrast, due to the slow increase of living biomass, Afforestations are a “more slow process with increasing importance” in terms of carbon accumulation.

Table 11-5 shows the detailed deforestation events 1990-2010.

Table 11-5 Deforestation data communicated by the Office of Forests, Nature and Land Management (OFNLM) to Office of Environmental Protection (OEP).

Year	Owner of forest	cause / location	deforested area (m2)	area cumul. (kha)
altitudinal belt 1 [<600m]				
1990	Gemeinde Vaduz	Regierungsviertel	3350	0.00034
1994	Gemeinde Eschen	Deponie Rheinau	62000	0.00654
1995	Gemeinde Ruggell	Erweiterung Industriezone	5160	0.00705
1995	Gemeinde Triesen	Regenüberlaufbecken Leitawie	900	0.00714
1996	Gemeinde Vaduz	Erweiterung Tennisplätze	1330	0.00727
1998	Gemeinde Schaan	Deponie Ställa	3320	0.00761
2000	Gemeinde Gamprin	ARA, Bendern	10500	0.00866
2000	Gemeinde Ruggell	Erweiterung Steinbruch	5000	0.00916
2001	Gemeinde Schaan	Deponie Ställa	18000	0.01096
2002	Gemeinde Schaan	Deponie Ställa	10100	0.01197
2003	Gemeinde Gamprin	Betonwerk Wilhelm Büchel	950	0.01206
2003	Gemeinde Triesen	Deponie Säga	6000	0.01266
2003	Gemeinde Vaduz	Deponie Rain	8000	0.01346
2004	Gemeinde Gamprin	Erstellung Trottoir "Kehla"	735	0.01353
2004	Gemeinde Schaan	Deponie Ställa	18800	0.01541
2004	Gemeinde Triesenberg	Arealerweiterung Leitawies	3995	0.01581
2005	Gemeinde Vaduz	Deponie Rain	9000	0.01671
2005	Gemeinde Vaduz	Fussballplatzausbau	1510	0.01687
2006	Gemeinde Ruggell	Erweiterung Steinbruch	7200	0.01759
2007	Gemeinde Triesen	Erweiterung Motocrosspiste	1200	0.01771
2008	Gemeinde Balzers	Unterhaltsweg Rheindamm	1000	0.01781
2008	Gemeinde Schaan	Erstellung Dampfleitung	2210	0.01803
2009	Gemeinde Ruggell	Gewerbezone "Flandera"	4470	0.01847
altitudinal belt 2 [600-1200m]				
1992	Gemeinde Triesenberg	Wohncontainer (!)	1095	0.00011
1998	Gemeinde Triesenberg	Werkhöfe Guferwald	2350	0.00034
2002	Gemeinde Triesen	Erweiterung Sportplatz T'berg	9850	0.00133
2006	Gemeinde Triesenberg	Aussiedlungsbetriebe Studa	1710	0.00150
altitudinal belt 3 [>1200m]				
2006	Gemeinde Vaduz	Bergbahnen Malbun	7630	0.00076
Total 2009-2010				**0.00000**
Total Deforestation 1990-2010				**0.02074**

The numbers for afforestations and deforestations are implemented in the KP-LULUCF tables (see Table 11-2)

- <u>Afforestation:</u>
  - The cumulated area of afforestation 1990-2009 is reported in the cell from “Afforestation and reforestation” to “Afforestation and reforestation” (0.61 kha). Calculation based on values presented in Table 7-6.
  - The area change between the previous and the current inventory year, 2009 and 2010 respectively, is reported in the cell from “Other” to “Afforestation and Reforestation” (0.01 kha). Calculation based on values presented in Table 7-6.
- <u>Deforestation:</u>
  - The cumulated area of deforestation 1990-2009 is reported in the cell from “Deforestation” to “Deforestation” (0.02 kha, see total 1990-2009 Table 11-5)
  - The area change between the previous and the current inventory year, 2009 and 2010 respectively, is reported in the cell from “Forest management” to “Deforestation” As no deforestation has occurred in 2010, “NO” is reported. Even though Liechtenstein has decided not to account for Article 3.4. activities this figure has to be reported under Art. 3.4. activities, being relevant for Art. 3.3. acitivity deforestation.

11.4.1 Information that demonstrates that Activities under Article 3.3. began on or after 1 January 1990 and before December 2012 and are direct Human-induced

Liechtenstein's definitions of afforestation and deforestation only consider directly human-induced activities.

Reforestation

For more than 100 years, the area of forest in Liechtenstein has been increasing, and a decrease in forest area as a result of deforestation is prohibited by the National Law on Forests with article 6 (Government 1991). Therefore, reforestation of areas not forested for a period of at least 50 years does not occur in Liechtenstein. Liechtenstein therefore, only has to consider afforestation and deforestation under Article 3, paragraph 3.

Afforestation

The annual rate of Afforestation since 1990 is assessed by AREA (see Chapter 7.3.2.2). For reporting under the Kyoto Protocol, afforested areas always remain in the "afforestation" category. Therefore, the area of Afforestations is increasing since 1990.

Afforestations since 1990 were not subject to harvesting or clear cutting, since there are no forests with such short rotation lengths.

Deforestation

Deforestation is prohibited by the National Law on Forests with article 6 (Government 1991) and exceptions need governmental authorisation. The authorisation documents are collected by the Office of Forest, Nature and Landscape (OFNLM) and are annually reported to the Parliament. Therefore data on Deforestation is very detailed (area of the forest, reason for deforestation). Only deforestations carried out after 1 January 1990 are considered.

11.4.2 Information on how Harvesting or Forest Disturbance that is followed by the Re-Establishment of Forest is distinguished from Deforestation

Liechtenstein's definition for deforestation only covers permanent conversions from forest land into non-forest land and thus implicitly distinguishes between permanent conversions and transient situations like harvesting or forest disturbance.

11.4.3 Information on the Size and Geographical Location of Forest Areas that have lost Forest Cover but which are not yet classified as Deforested

There is a discrepancy between the deforested area retrieved from the "Rodungsstatistik" (Table 11-5) on the one hand and the area which changes from a forest-land combination category to a non-forest land combination category displayed in the Land-Transition Matrix, as determined by AREA (see also Chapter 7.3.2.2), on the other hand.

To investigate these differences between both data bases a study was initiated in Switzerland in autumn 2009 (Rihm et al. 2010). Preliminary results show that a major part of the conversions from a forest-land combination category to a non-forest land combination category is due to the management of forest edges or the management of open forests on agricultural areas (so called "Wytweiden"). These management practices are part of the sustainable management of Swiss forests. A temporal decline in tree cover can lead to the conversion in a non-forest land category (e.g. CC32 grassland with perennial woody biomass) according to the AREA classification. These results hold also true for Liechtenstein as the same methodology was applied and therefore, we consider these conversions also as temporal and therefore do not report these changes as “deforestation”.

In the next submission, this section will be updated and if necessary corrected for the deforested area, based on the results of the study by Rihm et al. (2010).

11.5 Article 3.4

Liechtenstein has decided not to account for activities under Article. 3.4

11.6 Other Information

11.6.1 Key Category Analysis for Article 3.3. activities

As stated in the IPCC Good Practice Guidance for LULUCF (IPCC 2003), the basis for assessment of key categories under Articles 3.3 and 3.4 of the Kyoto Protocol is the same as the assessment made for the UNFCCC inventory. Note that Liechtenstein has elected to not account for LULUCF activities under Article 3.4 during the first commitment period (OEP 2006a). Therefore only the categories afforestation/reforestation and deforestation are reported for the KP Inventory.

Among the key categories from the LULUCF sector in the UNFCCC inventory, there are three categories which have a relationship to afforestation/reforestation or deforestation, according to table 5.4.4 in the IPCC Good Practice Guidance for LULUCF:

- 5C2 Land converted to Grassland: related to deforestation
- 5D2 Land converted to Wetlands: related to deforestation
- 5E2 Land converted to Settlements: related to deforestation

Afforestation occurs in more than one category of the UNFCCC inventory. As recommended by the IPCC Good Practice Guidance for LULUCF, in this case the total emissions and removals from the activity are considered for purposes of the key category analysis. The total from the activity afforestation in 2010, as reported with the present submission, is a removal of 3.11 Gg CO_2. The smallest category that is identified as key category in the UNFCCC inventory (combined KCA without and with LULUCF categories) is 4D3 Indirect Emissions from Agricultural Soils with 2.47 Gg CO_2 emissions. This means that the total for afforestation is greater than the emissions from the smallest category that is identified as key in the UNFCCC inventory. Therefore Afforestation is considered to be a key category whereas Deforestation with only 0.14 Gg CO_2 emissions is not a key category.

11.7 Information Relating to Article 6

Liechtenstein currently does not host projects under the Joint Implementation Mechanism.

12 Accounting on Kyoto Units

12.1 Background Information

The standard electronic format (SEF) is part of the submission under Article 7.1 of the Kyoto Protocol in accordance with decisions 11/CP.4, 14/CMP1 and 15/CMP.1. The SEF Tables have been developed to facilitate the reporting and the review of Kyoto Protocol units by Annex-I Parties.

Additionally several reports for the Standard Independent Assessment Report (SIAR) have to be submitted by a Party, matching the requirements of Decision 14/CMP.1 and 15/CMP.1

12.2 Summary of Information Reported in the SEF Tables

The tables of the Standard Electronic Format (SEF) providing all necessary information on Kyoto units (AAU, CER, ERU, tCER, lCER and RMU) for 2011 have been submitted together with this report (NIR 2011). Details are disclosed in the corresponding file SEF_LI_2011_3_11-27-32 22-2-2011.

12.3 Discrepancies and Notifications

The following information on Kyoto units are covered by the Annex of Decision 15/CMP.1 Part I.E para 12 to 17:

Para. 12: No discrepant transactions occurred in 2010

Para. 13/14: No CDM notifications occurred in 2010.

Para. 15: No non-replacements occurred in 2010.

Para. 16: No invalid units exist as at 31 December 2010.

Para. 17: Necessary actions have been undertaken to correct any problem causing a discrepancy in the reporting year 2010. All relevant transactions were terminated.

12.4 Publicly Accessible Information

Pursuant to paragraphs 44 to 48 in section I.E of the annex to decision 13/CMP.1, Liechtenstein makes non-confidential information available to public using Registry Homepage and/or user interface. In Liechtenstein the following information is considered as non-confidental and publicly accessible on website (http://www.llv.li/amtsstellen/llv-aus-emissionshandel_en.htm) and/or user interface (www.emissionshandelsregister.li):

1) List of legal entities holding an account in the national registry

2) List of installations in line with the European emissions trading directive

3) List of accounts opened in the national registry

4) Annual summary of quantity of units per type of operation performed in the national registry

5) Compliance status of installations concerning the declaration of verified emissions, grouped by operators

6) Summary statement on the quantity of allowances surrendered by an operator for compliance

7) Report on consolidated position of all installations verified emissions compared with total allowances surrendered

8) Report on the assessment of operator's compliance, grouped by operators

9) List of non-compliant installations

10) Verified emissions table

- Additionally all required information on Article 6 projects (JI) is available on the internet website of the Office of Environmental Protection (OEP; http://www.llv.li/amtsstellen/llv-aus-emissionshandel_en/llv-aus-emissionshandelsregister_flexible_mechanismen_en/llv-aus-emissionshandel-genehmigte_projekte_en.htm). These informations comprise name of projects, host counties, available documents and dates.

Personalized data and some information of individual holding accounts are considered as business secrets and the disclosure may prejudice their competiveness. Information on acquiring and transferring accounts of legal entities (companies) is therefore regarded as personal data. According to article 20 of the national Act on Data Protection (Datenschutzgesetz vom 14. März 2002, LGBl Nr.55) enacts that public authorities may disclose personal data if there is a legal basis or if there is an overriding public interest. Neither case is fulfilled and therefore the registry of Liechtenstein can not make the information on acquiring and / or transferring accounts publicly available. All related information is considered as **confidential** and therefore paragraphs 44-40 of the Annex to Decision 13/CMP.1 are not applicable.

12.5 Calculation of the Commitment Period Reserve (CPR)

No changes compared to submission 2011. According to the Annex of decision 11/CMP.1, each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90 per cent of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8, of the Kyoto Protocol, or 100 per cent of five times its most recently reviewed inventory, whichever is lowest. In line with these specifications, Liechtenstein reported its commitment period reserve to be 950.061 Gg CO_2 eq based on the assigned amount, which is consistent with the initial review report 2006 (FCCC/IRR 2007).

Liechtenstein considers that the „most recently reviewed inventory“ refers to the inventory 2007 presented in the current NIR.

In order to determine which of the two methods to calculate the commitment period reserve results in the lower value, the results of both methods are indicated in Table A - 19

Table 12-1 Calculation of Liechtenstein's commitment period reserve 2010.

Method 1		**Method 2**	
Assigned amount calculated pursuant to Art. 3, para. 7 and 8 of the Kyoto protocol (five times 92% of 1990 emissions), see OEP (2007b) [Gg CO_2 equivalent]	1'055.623	2010 emissions without LULUCF,see Table 2-1 [Gg CO_2 equivalent]	233.20
90% of the assigned amount [Gg CO_2 equivalent]	950.061	100% of five times the 2010 emissions without LULUCF [Gg CO_2 equivalent]	1166.00

The CPR remains unchanged since method 1 still results in the lower value and is therefore used to calculate the minimum amount of the CPR. **The commitment period reserve of Liechtenstein should therefore not drop below 950.061 Gg CO_2 equivalent (0.950061 million tonnes CO_2 equivalent).**

12.6 KP-LULUCF Accounting

Liechtenstein does not account for KP LULUCF. Therefore the inventory is understood to be calculated without LULUCF emissions/removals.

13 Changes in National System

The National System remained unchanged in the inventory cycle 2010.

14 Changes in National Registry

The national inventory system remains unchanged compared to the description given in the With reference to paragraph 32(d) of annex II.E to the Decision 15/ CMP.1 the changes listed below have been performed compared to the description given in the NIR 2008 under Kyoto Protocol submitted in April 2011. These changes fulfill the new requirements set out by the European Comission in the amended Registry Regulation 2216/2004. Other paragraphs remain unaffected.

Software upgrade:

SERINGAS Registry Software application have been upgraded from Version 4.3.1 to Version 5.2.1. The new software includes the following major changes:

- **Reports settings:** Possibility of setting the level of confidentiality and date of publication for each report.
- **Manual reversal of transaction:** Creation of a new transaction named "Manual reversal of transaction" in order to manage a reverse transfer of the finalized transaction (status "T") without any SOAP messages exchange between the registry and CITL (internal transfer).
- **Compliance management:** Compliance figures and correction factor implementation Installations' verified emissions status management: Correction of VE, new statuses etc.
- **Confidentiality management:** Certain information of the account representatives can be as available as hidden from the public according to request of the given account holder.
- **Automatic blocking:** New account statuses management, new report, automatic notifications etc.
- **Permit date management:** new mandatory information to be provided to CITL.
- **Retirement and conversion:** All allowances are to be converted into AAU before being retired in accordance with a new REGREG procedure.
- **Fees management:** New mandatory information to be provided to CITL.
- **Automatic NAP:** NAP management via Web Services in addition to existent already NAP initialization process by XML file.
- **Audit trail:** Possibility to perform a search only by a start block. New error messages.
- **Transactions list:** New search criteria (by transaction status and by unit type).
- **Account management:** Possibility to delete INACTIVE account without its activation.
- **Registry management:** Possibility to block access to the registry for all users except RSA by one click.
- **NAP management:** Possibility to use the same installation ID for opening of 2 or more OHAs (only one OHA can be active).
- **Transaction contents:** Possibility to view all blocks contained in a transaction criteria (by transaction status and by unit type).

Due to these changes, a conformance testing had to be performed with the CITL based on the Test Plan provided by the European Comission / CITL Administrator. The testing was finalized successfully by the registry of Liechtenstein. The Test protocol is available for reviewers if needed.

Testprotokoll – EU-ETS Testplan, Version 5.2.1.7

(Remote Test 02-21.11.2011)

Projekt	EU-ETS Remote Test - Liechtenstein
Projekt -ID	REG_LI_Klima_8643
Projektleiter	Patrick Insinna
Kontrolle durch	Andreas Gstöhl
Genehmigung durch	Helmut Kindle
Status	genehmigt

Änderungsprotokoll

Datum	Version	Beschreibung	Autor
02-21.11.2011	1.0	Erstentwurf	P. Insinna /L. Bessemans
	1.1	Amtsinterne Kontrolle	P. Insinna
	1.2	Überarbeitung	L.Bessemans
	2.0	Genehmigung	H. Kindle
	3.0	Final	P. Insinna

Definitionen, Akronyme und Abkürzungen

ITL: Independent Transaction Log
CITL: Community Independent Transaction Log
CDC: Caisse des Depots et Consignations
RA: Register-Administrator
CP: Verpflichtungsperiode (commitment period)
CPR: Commitment Period Reserve
PA: Party Holding Account , Nationalkonto
OHA: Operator Holding Account, Betreiberkonto oder Anlagenkonto
PHA: Personal Account, Personenkonto

Inhaltsverzeichnis

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Figure 15-1: Frontpage of EU conformance test protocol for Registry Liechtenstein

15 Minimization of Adverse Impacts in Accordance with Article 3, Paragraph 14

The Convention (Art. 4 §8 and §10) and its Kyoto Protocol (Art. 2 §3 and Art. 3 §14) commit Parties to strive to implement climate policies and measures in such a way as to minimize adverse economic, social and environmental impacts on developing countries when responding to climate change. The concrete assessment of potential impacts on developing countries is extremely complex and uncertain, as the effects are often indirect, potentially positive and negative in nature, displaced over time and interacting with other policies, including those applied in developing countries. Liechtenstein has implemented different instruments striving at minimizing potential adverse impacts of its climate change response measures. Liechtenstein is implementing climate change response measures in all sectors and for different gases. The policies and measures are very much compatible and consistent with those of the European Union in order to avoid trade distortion, non-tariff barriers to trade and to set similar incentives. In accordance with international law, this approach strives at ensuring that Liechtenstein is implementing those climate change response measures, which are least trade distortive and do not create unnecessary barriers to trade.

Tax exemption in Switzerland and consequently also Liechtenstein (tax union) for biofuels is limited to fuels that meet ecological and social criteria. The conditions are set out in such a way that biofuels do not compete with food production and are not causing degradation of rainforests or other valuable ecosystems. The Swiss Centre for Technology Assessment (TA-Swiss) published a study on the assessment of social and environmental impacts of the use of second generation biomass fuels with the following result: “In summary, 2nd generation biofuels allow a more sustainable mobility than both fossil and 1st generation biofuels based on agriculture. Due to the limited availability of both waste feedstocks and cultivation area, however, sustainable bioenergy-based mobility is restricted to clearly less than 8% of individual mobility in Switzerland, if constant mobility and fleet efficiency is assumed. Nevertheless, 2nd generation biofuels may play a relevant complementary part in supplying our future mobility, in particular for long distance transport and aviation where electric mobility is less suitable.” (TA-SWISS 2010).

The Swiss Academies of Arts and Sciences have started a project to assess possible conflicts and synergies between the expansion of renewable energy production and land management. Many forms of renewable energy (solar, wind, water, biomass, geothermal) require considerable floor space and lead to changes in land use, ecosystems, and the views of places and landscape. Large-scale use of areas for energy production thus have to be planned considering the maintenance of ecosystem services, protection of biodiversity, or natural sceneries which are important for tourism. A project report is expected at the end of 2010 (at the moment – Febraury 2011 - not published yet).

An assessment of conflicts and synergies between policies and measures to mitigate climate change and biodiversity protection has been made by the biodiversity forum and ProClim in 2008 (SCNAT 2008). While there are several synergies in the area of ecosystem management and agriculture, conflicts exist concerning the use of renewable energies, be it the adverse effects of increased hydroelectricity generation on natural water flows or the impacts of other renewable energy systems on natural landscapes and ecosystems. The report gives recommendations on how to take advantage of synergies and how to detect conflicts in an early stage.

16 Other Information

No other information to be reported.

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Annexes

Annex 1: Key Category Analysis

A1.1 Complete KCA 2010 without LULUCF categories

Table A - 1 Complete Key Category Analysis for 2010 without LULUCF categories (Level and Trend Assessment).

IPCC Source Categories (and fuels if applicable) Level Assessment					Direct GHG	Base Year 1990 Estimate (Mt Carbon Equivalent)	Current Year Estimate (Mt Carbon Equivalent)	Level Assessment	Cumulative Total Column E-L
						[Gg CO2eq]	[Gg CO2eq]		
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	60.53	46.62	0.20	0.20
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Liquid Fuels	CO2	57.10	30.98	0.13	0.33
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	14.77	29.65	0.13	0.46
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	2.51	26.26	0.11	0.57
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Gaseous Fuels	CO2	8.70	21.23	0.09	0.66
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Gaseous Fuels	CO2	16.48	12.09	0.05	0.72
4A	4. Agriculture	A. Enteric Fermentation			CH4	10.42	10.45	0.04	0.76
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	18.74	10.25	0.04	0.80
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Liquid Fuels	CO2	18.74	10.24	0.04	0.85
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			HFC	0.00	6.64	0.03	0.88
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	5.45	5.24	0.02	0.90
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	2.36	3.47	0.01	0.91
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CO2	0.00	3.27	0.01	0.93
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	0.12	3.09	0.01	0.94
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	2.72	2.47	0.01	0.95
4B	4. Agriculture	B. Manure Management			CH4	2.16	1.98	0.01	0.96
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	1.30	1.41	0.01	0.97
4B	4. Agriculture	B. Manure Management			N2O	1.21	1.36	0.01	0.97
1B2	1. Energy	B. Fugitive Emissions from	2. Oil and Natural Gas		CH4	0.32	1.06	0.00	0.98
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	0.99	1.06	0.00	0.98
6B	6. Waste	B. Wastewater Handling			N2O	0.79	0.90	0.00	0.99
6D	6. Waste	D. Other			CH4	0.40	0.57	0.00	0.99
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	0.13	0.56	0.00	0.99
3	3. Solvent and Other Product Use				CO2	0.08	0.27	0.00	0.99
3	3. Solvent and Other Product Use				N2O	0.47	0.25	0.00	0.99
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	0.03	0.24	0.00	0.99
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	0.73	0.22	0.00	0.99
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	0.08	0.14	0.00	0.99
6D	6. Waste	D. Other			N2O	0.08	0.12	0.00	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	0.54	0.11	0.00	1.00
6B	6. Waste	B. Wastewater Handling			CH4	0.07	0.10	0.00	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.01	0.09	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Liquid Fuels	N2O	0.14	0.08	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.05	0.08	0.00	1.00
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			PFC	NO	0.07	0.00	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.06	0.00	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	0.01	0.06	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Biomass	N2O	0.01	0.06	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Gaseous Fuels	CH4	0.02	0.05	0.00	1.00
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	0.03	0.04	0.00	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	0.01	0.04	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.00	0.03	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Gaseous Fuels	CH4	0.04	0.03	0.00	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	0.05	0.03	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Liquid Fuels	N2O	0.05	0.03	0.00	1.00
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			SF6	NO	0.02	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Biomass	CH4	0.00	0.02	0.00	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	0.01	0.02	0.00	1.00
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	0.22	0.01	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Gaseous Fuels	N2O	0.00	0.01	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Liquid Fuels	CH4	0.02	0.01	0.00	1.00
6C	6. Waste	C. Waste Incineration			CO2	0.01	0.01	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Gaseous Fuels	N2O	0.01	0.01	0.00	1.00
6C	6. Waste	C. Waste Incineration			CH4	0.01	0.01	0.00	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	0.09	0.00	0.00	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	0.01	0.00	0.00	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	0.01	0.00	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Liquid Fuels	CH4	0.01	0.00	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.00	0.00	0.00	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.00	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.00	0.00	0.00	1.00
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	0.00	0.00	0.00	1.00
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	0.00	0.00	0.00	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	0.01	0.00	0.00	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	0.00	0.00	0.00	1.00

(Cont’d next page)

IPCC Source Categories (and fuels if applicable) Level Assessment					Direct GHG	Base Year 1990 Estimate (Mt Carbon Equivalent)	Current Year Estimate (Mt Carbon Equivalent)	Level Assessment	Cumulative Total Column E-L
						[Gg CO2eq]	[Gg CO2eq]		
6C	6. Waste	C. Waste Incineration			N2O	0.00	0.00	0.00	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.00	0.00	0.00	1.00
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.00	0.00	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	NO	NO	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	NO	NO	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	NO	NO	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.00	0.00	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.00	0.00	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CH4	0.00	0.00	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	0.00	0.00	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.00	0.00	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	0.00	0.00	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Solid Fuels	CO2	NO	NO	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Other Fuels	CO2	NO	NO	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Solid Fuels	CH4	0.00	0.00	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Biomass	CH4	0.00	0.00	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Other Fuels	CH4	0.00	0.00	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Solid Fuels	N2O	0.00	0.00	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Biomass	N2O	0.00	0.00	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Other Fuels	N2O	0.00	0.00	0.00	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CH4	0.00	0.00	0.00	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	N2O	0.00	0.00	0.00	1.00
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	NO	NO	0.00	1.00
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CH4	0.00	0.00	0.00	1.00
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	0.00	0.00	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Solid Fuels	CO2	NO	NO	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Solid Fuels	CH4	0.00	0.00	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Solid Fuels	N2O	0.00	0.00	0.00	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	NO	NO	0.00	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.00	0.00	0.00	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	0.00	0.00	0.00	1.00
1B2	1. Energy	B. Fugitive Emissions from	2. Oil and Natural Gas		CO2	NA,NO	NA,NO	0.00	1.00
1B2	1. Energy	B. Fugitive Emissions from	2. Oil and Natural Gas		N2O	NA,NO	NA,NO	0.00	1.00
2A	2. Industrial Proc.	A. Mineral Products			CO2	NO	NO	0.00	1.00
2A	2. Industrial Proc.	A. Mineral Products			CH4	NO	NO	0.00	1.00
2A	2. Industrial Proc.	A. Mineral Products			N2O	NO	NO	0.00	1.00
2B	2. Industrial Proc.	B. Chemical Industry			CO2	NO	NO	0.00	1.00
2B	2. Industrial Proc.	B. Chemical Industry			CH4	NO	NO	0.00	1.00
2B	2. Industrial Proc.	B. Chemical Industry			N2O	NO	NO	0.00	1.00
2C	2. Industrial Proc.	C. Metal Production			CO2	NO	NO	0.00	1.00
2C	2. Industrial Proc.	C. Metal Production			CH4	NO	NO	0.00	1.00
2C	2. Industrial Proc.	C. Metal Production			N2O	NO	NO	0.00	1.00
2D	2. Industrial Proc.	D. Other Production			CO2	NO	NO	0.00	1.00
2E	2. Industrial Proc.	E. Production of Halocarbons and SF6			CO2	0.00	0.00	0.00	1.00
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			CO2	0.00	0.00	0.00	1.00
2G	2. Industrial Proc.	G. Other			CO2	NO	NO	0.00	1.00
2G	2. Industrial Proc.	G. Other			CH4	NO	NO	0.00	1.00
2G	2. Industrial Proc.	G. Other			N2O	NO	NO	0.00	1.00
4C	4. Agriculture	C. Rice Cultivation			CH4	NA,NO	NA,NO	0.00	1.00
4D	4. Agriculture	D. Agricultural Soils			CH4	NA,NO	NA,NO	0.00	1.00
4E	4. Agriculture	E. Prescribed Burning of Savannas			CH4	NA	NA	0.00	1.00
4E	4. Agriculture	E. Prescribed Burning of Savannas			N2O	NA	NA	0.00	1.00
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH4	NA,NO	NA,NO	0.00	1.00
4F	4. Agriculture	F. Field Burning of Agricultural Residues			N2O	NA,NO	NA,NO	0.00	1.00
4G	4. Agriculture	G. Other			CH4	NA	NA	0.00	1.00
4G	4. Agriculture	G. Other			N2O	NA	NA	0.00	1.00
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	NO	NO	0.00	1.00
6D	6. Waste	D. Other			CO2	NO	NO	0.00	1.00
TOTAL					*All*	*228.87*	*233.17*	*1.00*	*1.00*

IPCC Source Categories (and fuels if applicable) Trend Assessment					Direct GHG	Base Year 1990 Estimate	Current Year Estimate	Trend Assessment	Cumulative Total Col. F-T
						[Gg CO2eq]	[Gg CO2eq]		
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	57.10	30.98	0.114444	0.20
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	2.51	26.26	0.099786	0.38
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	60.53	46.62	0.063345	0.49
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	14.77	29.65	0.061464	0.60
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	8.70	21.23	0.052061	0.69
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	18.74	10.24	0.037271	0.76
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	18.74	10.25	0.037235	0.82
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			HFC	0.00	6.64	0.027967	0.87
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	16.48	12.09	0.019818	0.91
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CO2	0.00	3.27	0.013753	0.93
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	0.12	3.09	0.012493	0.95
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	2.36	3.47	0.004457	0.96
1B2	1. Energy	B. Fugitive Emissions from F	2. Oil and Natural Gas		CH4	0.32	1.06	0.003098	0.97
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	0.73	0.22	0.002208	0.97
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	0.54	0.11	0.001853	0.97
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	0.13	0.56	0.001782	0.98
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	5.45	5.24	0.001355	0.98
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	2.72	2.47	0.001264	0.98
3	3. Solvent and Other Product Use				N2O	0.47	0.25	0.000951	0.98
4B	4. Agriculture	B. Manure Management			CH4	2.16	1.98	0.000930	0.98
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	0.03	0.24	0.000883	0.99
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	0.22	0.01	0.000880	0.99
3	3. Solvent and Other Product Use				CO2	0.08	0.27	0.000790	0.99
4A	4. Agriculture	A. Enteric Fermentation			CH4	10.42	10.45	0.000674	0.99
6D	6. Waste	D. Other			CH4	0.40	0.57	0.000657	0.99
4B	4. Agriculture	B. Manure Management			N2O	1.21	1.36	0.000496	0.99
6B	6. Waste	B. Wastewater Handling			N2O	0.79	0.90	0.000402	0.99
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	0.09	0.00	0.000371	0.99
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	1.30	1.41	0.000371	0.99
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.01	0.09	0.000337	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	0.14	0.08	0.000283	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.06	0.000263	1.00
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	0.08	0.14	0.000253	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	0.01	0.06	0.000229	1.00
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	0.99	1.06	0.000211	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	0.01	0.06	0.000180	1.00
6D	6. Waste	D. Other			N2O	0.08	0.12	0.000136	1.00
6B	6. Waste	B. Wastewater Handling			CH4	0.07	0.10	0.000123	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	0.01	0.04	0.000120	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	0.02	0.05	0.000119	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.00	0.03	0.000119	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	N2O	0.05	0.03	0.000094	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	0.05	0.03	0.000094	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.05	0.08	0.000091	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	0.00	0.02	0.000061	1.00
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	0.03	0.04	0.000054	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CH4	0.04	0.03	0.000045	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	0.02	0.01	0.000034	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.00	0.01	0.000029	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	0.01	0.00	0.000025	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	0.01	0.00	0.000019	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	N2O	0.01	0.01	0.000011	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CH4	0.01	0.00	0.000011	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	0.01	0.00	0.000011	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.00	0.000008	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.00	0.00	0.000007	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	0.01	0.02	0.000004	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.00	0.00	0.000003	1.00
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	0.00	0.00	0.000002	1.00
6C	6. Waste	C. Waste Incineration			CO2	0.01	0.01	0.000002	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.00	0.00	0.000002	1.00
6C	6. Waste	C. Waste Incineration			CH4	0.01	0.01	0.000001	1.00
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	0.00	0.00	0.000001	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	0.00	0.00	0.000000	1.00
6C	6. Waste	C. Waste Incineration			N2O	0.00	0.00	0.000000	1.00

(Cont’d next page)

IPCC Source Categories (and fuels if applicable) Trend Assessment					Direct GHG	Base Year 1990 Estimate	Current Year Estimate	Trend Assessment	Cumulative Total Col. F-T
						[Gg CO2eq]	[Gg CO2eq]		
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.00	0.00	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	NO	NO	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	NO	NO	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	NO	NO	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.00	0.00	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.00	0.00	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CH4	0.00	0.00	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	0.00	0.00	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.00	0.00	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	0.00	0.00	0.000000	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CO2	NO	NO	0.000000	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	CO2	NO	NO	0.000000	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CH4	0.00	0.00	0.000000	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Biomass	CH4	0.00	0.00	0.000000	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	CH4	0.00	0.00	0.000000	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	N2O	0.00	0.00	0.000000	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Biomass	N2O	0.00	0.00	0.000000	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	N2O	0.00	0.00	0.000000	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CH4	0.00	0.00	0.000000	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	N2O	0.00	0.00	0.000000	1.00
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	NO	NO	0.000000	1.00
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CH4	0.00	0.00	0.000000	1.00
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	0.00	0.00	0.000000	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CO2	NO	NO	0.000000	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CH4	0.00	0.00	0.000000	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	N2O	0.00	0.00	0.000000	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	NO	NO	0.000000	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.00	0.00	0.000000	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	0.00	0.00	0.000000	1.00
1B2	1. Energy	B. Fugitive Emissions from F	2. Oil and Natural Gas		CO2	NA,NO	NA,NO	0.000000	1.00
1B2	1. Energy	B. Fugitive Emissions from F	2. Oil and Natural Gas		N2O	NA,NO	NA,NO	0.000000	1.00
2A	2. Industrial Proc.	A. Mineral Products			CO2	NO	NO	0.000000	1.00
2A	2. Industrial Proc.	A. Mineral Products			CH4	NO	NO	0.000000	1.00
2A	2. Industrial Proc.	A. Mineral Products			N2O	NO	NO	0.000000	1.00
2B	2. Industrial Proc.	B. Chemical Industry			CO2	NO	NO	0.000000	1.00
2B	2. Industrial Proc.	B. Chemical Industry			CH4	NO	NO	0.000000	1.00
2B	2. Industrial Proc.	B. Chemical Industry			N2O	NO	NO	0.000000	1.00
2C	2. Industrial Proc.	C. Metal Production			CO2	NO	NO	0.000000	1.00
2C	2. Industrial Proc.	C. Metal Production			CH4	NO	NO	0.000000	1.00
2C	2. Industrial Proc.	C. Metal Production			N2O	NO	NO	0.000000	1.00
2D	2. Industrial Proc.	D. Other Production			CO2	NO	NO	0.000000	1.00
2E	2. Industrial Proc.	E. Production of Halocarbons and SF6			CO2	0.00	0.00	0.000000	1.00
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			PFC	NO	0.07	0.000000	1.00
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			SF6	NO	0.02	0.000000	1.00
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			CO2	0.00	0.00	0.000000	1.00
2G	2. Industrial Proc.	G. Other			CO2	NO	NO	0.000000	1.00
2G	2. Industrial Proc.	G. Other			CH4	NO	NO	0.000000	1.00
2G	2. Industrial Proc.	G. Other			N2O	NO	NO	0.000000	1.00
4C	4. Agriculture	C. Rice Cultivation			CH4	NA,NO	NA,NO	0.000000	1.00
4D	4. Agriculture	D. Agricultural Soils			CH4	NA,NO	NA,NO	0.000000	1.00
4E	4. Agriculture	E. Prescribed Burning of Savannas			CH4	NA	NA	0.000000	1.00
4E	4. Agriculture	E. Prescribed Burning of Savannas			N2O	NA	NA	0.000000	1.00
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH4	NA,NO	NA,NO	0.000000	1.00
4F	4. Agriculture	F. Field Burning of Agricultural Residues			N2O	NA,NO	NA,NO	0.000000	1.00
4G	4. Agriculture	G. Other			CH4	NA	NA	0.000000	1.00
4G	4. Agriculture	G. Other			N2O	NA	NA	0.000000	1.00
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	NO	NO	0.000000	1.00
6D	6. Waste	D. Other			CO2	NO	NO	0.000000	1.00
TOTAL					*All*	*228.87*	*233.17*		

Table A - 2 Complete Key Category Analysis for 2010 without LULUCF categories (Summary).

IPCC Source Categories (and fuels if applicable) Source Category Analysis Summary					Direct GHG	Key Source Category Flag	If Column C is Yes, Criteria for Identification
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	yes	Level, Trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CH4	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Biomass	CH4	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Biomass	N2O	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	yes	Level, Trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CH4	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	N2O	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	yes	Level, Trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	N2O	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CH4	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	CO2	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	CH4	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	N2O	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CO2	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CH4	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	N2O	no	
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	no	
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	no	
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	no	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	no	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	no	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	yes	Level, Trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	no	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	no	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CO2	yes	Level, Trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CH4	no	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	N2O	no	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	yes	Level, Trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	no	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	no	
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviati		CO2	no	
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviati		CH4	no	
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviati		N2O	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	yes	Level, Trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	yes	Level, Trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CO2	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CH4	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	N2O	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	yes	Level, Trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	yes	Level, Trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	no	

(Cont'd next page)

IPCC Source Categories (and fuels if applicable) Source Category Analysis Summary					Direct GHG	Key Source Category Flag	If Column C is Yes, Criteria for Identification
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	no	
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	no	
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	no	
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	no	
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	no	
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	no	
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	no	
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	yes	Level
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	no	
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	no	
1B2	1. Energy	B. Fugitive Emissions from Fue	2. Oil and Natural Gas		CH4	no	
1B2	1. Energy	B. Fugitive Emissions from Fue	2. Oil and Natural Gas		CO2	no	
1B2	1. Energy	B. Fugitive Emissions from Fue	2. Oil and Natural Gas		N2O	no	
2A	2. Industrial Proc	A. Mineral Products			CO2	no	
2A	2. Industrial Proc	A. Mineral Products			CH4	no	
2A	2. Industrial Proc	A. Mineral Products			N2O	no	
2B	2. Industrial Proc	B. Chemical Industry			CO2	no	
2B	2. Industrial Proc	B. Chemical Industry			CH4	no	
2B	2. Industrial Proc	B. Chemical Industry			N2O	no	
2C	2. Industrial Proc	C. Metal Production			CO2	no	
2C	2. Industrial Proc	C. Metal Production			CH4	no	
2C	2. Industrial Proc	C. Metal Production			N2O	no	
2D	2. Industrial Proc	D. Other Production			CO2	no	
2E	2. Industrial Proc	E. Production of Halocarbons a			CO2	no	
2F	2. Industrial Proc	F. Consumption of Halocarbons			HFC	yes	Level, Trend
2F	2. Industrial Proc	F. Consumption of Halocarbons			PFC	no	
2F	2. Industrial Proc	F. Consumption of Halocarbons			SF6	no	
2F	2. Industrial Proc	F. Consumption of Halocarbons			CO2	no	
2G	2. Industrial Proc	G. Other			CO2	no	
2G	2. Industrial Proc	G. Other			CH4	no	
2G	2. Industrial Proc	G. Other			N2O	no	
3	3. Solvent and Ot				CO2	no	
3	3. Solvent and Ot				N2O	no	
4A	4. Agriculture	A. Enteric Fermentation			CH4	yes	Level
4B	4. Agriculture	B. Manure Management			CH4	no	
4B	4. Agriculture	B. Manure Management			N2O	no	
4C	4. Agriculture	C. Rice Cultivation			CH4	no	
4D	4. Agriculture	D. Agricultural Soils			CH4	no	
4D_o	4. Agriculture	D. Agricultural Soils without 4D			N2O	no	
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil			N2O	yes	Level
4D3	4. Agriculture	D. Agricultural Soils; Indirect Er			N2O	yes	Level
4E	4. Agriculture	E. Prescribed Burning of Savar			CH4	no	
4E	4. Agriculture	E. Prescribed Burning of Savar			N2O	no	
4F	4. Agriculture	F. Field Burning of Agricultural			CH4	no	
4F	4. Agriculture	F. Field Burning of Agricultural			N2O	no	
4G	4. Agriculture	G. Other			CH4	no	
4G	4. Agriculture	G. Other			N2O	no	
6A	6. Waste	A. Solid Waste Disposal on Lar			CH4	no	
6A	6. Waste	A. Solid Waste Disposal on Lar			CO2	no	
6B	6. Waste	B. Wastewater Handling			N2O	no	
6B	6. Waste	B. Wastewater Handling			CH4	no	
6C	6. Waste	C. Waste Incineration			CO2	no	
6C	6. Waste	C. Waste Incineration			CH4	no	
6C	6. Waste	C. Waste Incineration			N2O	no	
6D	6. Waste	D. Other			CH4	no	
6D	6. Waste	D. Other			N2O	no	
6D	6. Waste	D. Other			CO2	no	

A1.2 Complete KCA 2010 including LULUCF categories

Table A - 3 Liechtenstein's key categories in 2010 including LULUCF categories (Level and Trend Assessment). In accordance with GPG (IPCC 2000) estimates for removals are accounted with a positive sign.

IPCC Source Categories (and fuels if applicable) Level Assessment					Direct GHG	Base Year 1990 Estimate	Current Year Estimate	Level Assessment	Cumulative Total Column E-L
						[Gg CO2eq]	[Gg CO2eq]		
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	60.53	46.62	0.18	0.18
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	57.10	30.98	0.12	0.29
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	14.77	29.65	0.11	0.41
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	2.51	26.26	0.10	0.51
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	8.70	21.23	0.08	0.59
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO2	18.64	18.48	0.07	0.66
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CO2	16.48	12.09	0.05	0.70
4A	4. Agriculture	A. Enteric Fermentation			CH4	10.42	10.45	0.04	0.74
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	18.74	10.25	0.04	0.78
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CO2	18.74	10.24	0.04	0.82
2F	2. Industrial Pro	F. Consumption of Halocarbons and SF6			HFC	0.00	6.64	0.03	0.84
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	5.45	5.24	0.02	0.86
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO2	4.33	4.46	0.02	0.88
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	2.36	3.47	0.01	0.89
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO2	3.30	3.29	0.01	0.91
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CO2	0.00	3.27	0.01	0.92
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	0.12	3.09	0.01	0.93
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	2.72	2.47	0.01	0.94
4B	4. Agriculture	B. Manure Management			CH4	2.16	1.98	0.01	0.95
5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO2	2.13	1.70	0.01	0.95
5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland		CO2	0.01	1.69	0.01	0.96
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	1.30	1.41	0.01	0.96
4B	4. Agriculture	B. Manure Management			N2O	1.21	1.36	0.01	0.97
5F2	5. LULUCF	F. Other Land	2. Land converted to Other Land		CO2	0.44	1.15	0.00	0.97
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CH4	0.32	1.06	0.00	0.98
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	0.99	1.06	0.00	0.98
6B	6. Waste	B. Wastewater Handling			N2O	0.79	0.90	0.00	0.99
6D	6. Waste	D. Other			CH4	0.40	0.57	0.00	0.99
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	0.13	0.56	0.00	0.99
3	3. Solvent and Other Product Use				CO2	0.08	0.27	0.00	0.99
3	3. Solvent and Other Product Use				N2O	0.47	0.25	0.00	0.99
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	0.03	0.24	0.00	0.99
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	0.73	0.22	0.00	0.99
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	0.08	0.14	0.00	0.99
5D2	5. LULUCF	D. Wetlands	2. Land converted to Wetlands		CO2	0.16	0.13	0.00	0.99
6D	6. Waste	D. Other			N2O	0.08	0.12	0.00	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	0.54	0.11	0.00	1.00
6B	6. Waste	B. Wastewater Handling			CH4	0.07	0.10	0.00	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.01	0.09	0.00	1.00
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		CO2	0.11	0.08	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	0.14	0.08	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.05	0.08	0.00	1.00
2F	2. Industrial Pro	F. Consumption of Halocarbons and SF6			PFC	NO	0.07	0.00	1.00
5A2	5. LULUCF	A. Forest Land	2. Land converted to Forest Land		CO2	0.10	0.07	0.00	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.06	0.00	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	0.01	0.06	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	0.01	0.06	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	0.02	0.05	0.00	1.00
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	0.03	0.04	0.00	1.00
5E1	5. LULUCF	E. Settlements	1. Settlements remaining Settlements		CO2	0.05	0.04	0.00	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	0.01	0.04	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.00	0.03	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CH4	0.04	0.03	0.00	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	0.05	0.03	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	N2O	0.05	0.03	0.00	1.00
2F	2. Industrial Pro	F. Consumption of Halocarbons and SF6			SF6	NO	0.02	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	0.00	0.02	0.00	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	0.01	0.02	0.00	1.00
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	0.22	0.01	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.00	0.01	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	0.02	0.01	0.00	1.00
6C	6. Waste	C. Waste Incineration			CO2	0.01	0.01	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	N2O	0.01	0.01	0.00	1.00
6C	6. Waste	C. Waste Incineration			CH4	0.01	0.01	0.00	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	0.09	0.00	0.00	1.00
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		N2O	0.00	0.00	0.00	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	0.01	0.00	0.00	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	0.01	0.00	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CH4	0.01	0.00	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.00	0.00	0.00	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.00	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.00	0.00	0.00	1.00
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	0.00	0.00	0.00	1.00
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	0.00	0.00	0.00	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	0.01	0.00	0.00	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	0.00	0.00	0.00	1.00
6C	6. Waste	C. Waste Incineration			N2O	0.00	0.00	0.00	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.00	0.00	0.00	1.00
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.00	0.00	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	NO	NO	0.00	1.00

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IPCC Source Categories (and fuels if applicable) Level Assessment					Direct GHG	Base Year 1990 Estimate	Current Year Estimate	Level Assessment	Cumulative Total Column E-L
						[Gg CO2eq]	[Gg CO2eq]		
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	NO	NO	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	NO	NO	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.00	0.00	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.00	0.00	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CH4	0.00	0.00	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	0.00	0.00	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.00	0.00	0.00	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	0.00	0.00	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CO2	NO	NO	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CO2	NO	NO	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CH4	0.00	0.00	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	CH4	0.00	0.00	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CH4	0.00	0.00	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	N2O	0.00	0.00	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	N2O	0.00	0.00	0.00	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	N2O	0.00	0.00	0.00	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CH4	0.00	0.00	0.00	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	N2O	0.00	0.00	0.00	1.00
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	NO	NO	0.00	1.00
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CH4	0.00	0.00	0.00	1.00
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	0.00	0.00	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CO2	NO	NO	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CH4	0.00	0.00	0.00	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	N2O	0.00	0.00	0.00	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	NO	NO	0.00	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.00	0.00	0.00	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	0.00	0.00	0.00	1.00
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas		CO2	NA,NO	NA,NO	0.00	1.00
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas		N2O	NA,NO	NA,NO	0.00	1.00
2A	2. Industrial Proc	A. Mineral Products			CO2	NO	NO	0.00	1.00
2A	2. Industrial Proc	A. Mineral Products			CH4	NO	NO	0.00	1.00
2A	2. Industrial Proc	A. Mineral Products			N2O	NO	NO	0.00	1.00
2B	2. Industrial Proc	B. Chemical Industry			CO2	NO	NO	0.00	1.00
2B	2. Industrial Proc	B. Chemical Industry			CH4	NO	NO	0.00	1.00
2B	2. Industrial Proc	B. Chemical Industry			N2O	NO	NO	0.00	1.00
2C	2. Industrial Proc	C. Metal Production			CO2	NO	NO	0.00	1.00
2C	2. Industrial Proc	C. Metal Production			CH4	NO	NO	0.00	1.00
2C	2. Industrial Proc	C. Metal Production			N2O	NO	NO	0.00	1.00
2D	2. Industrial Proc	D. Other Production			CO2	NO	NO	0.00	1.00
2E	2. Industrial Proc	E. Production of Halocarbons and SF6			CO2	0.00	0.00	0.00	1.00
2F	2. Industrial Proc	F. Consumption of Halocarbons and SF6			CO2	0.00	0.00	0.00	1.00
2G	2. Industrial Proc	G. Other			CO2	NO	NO	0.00	1.00
2G	2. Industrial Proc	G. Other			CH4	NO	NO	0.00	1.00
2G	2. Industrial Proc	G. Other			N2O	NO	NO	0.00	1.00
4C	4. Agriculture	C. Rice Cultivation			CH4	NA,NO	NA,NO	0.00	1.00
4D	4. Agriculture	D. Agricultural Soils			CH4	NA,NO	NA,NO	0.00	1.00
4E	4. Agriculture	E. Prescribed Burning of Savannas			CH4	NA	NA	0.00	1.00
4E	4. Agriculture	E. Prescribed Burning of Savannas			N2O	NA	NA	0.00	1.00
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH4	NA,NO	NA,NO	0.00	1.00
4F	4. Agriculture	F. Field Burning of Agricultural Residues			N2O	NA,NO	NA,NO	0.00	1.00
4G	4. Agriculture	G. Other			CH4	NA	NA	0.00	1.00
4G	4. Agriculture	G. Other			N2O	NA	NA	0.00	1.00
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CH4	0.00	0.00	0.00	1.00
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		N2O	0.00	0.00	0.00	1.00
5D1	5. LULUCF	D. Wetlands	1. Wetlands remaining Wetlands		CO2	0.00	0.00	0.00	1.00
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	NO	NO	0.00	1.00
6D	6. Waste	D. Other			CO2	NO	NO	0.00	1.00
TOTAL					All	258.14	264.27	1.00	1.00

IPCC Source Categories (and fuels if applicable) Trend Assessment					Direct GHG	Base Year 1990 Estimate [Gg CO2eq]	Current Year Estimate [Gg CO2eq]	Trend Assessment	Cumulative Total Col. F-T
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	57.10	30.98	0.101535	0.20
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	2.51	26.26	0.087571	0.37
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	60.53	46.62	0.056732	0.48
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	14.77	29.65	0.053697	0.58
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	8.70	21.23	0.045552	0.67
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CO2	18.74	10.24	0.033070	0.74
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	18.74	10.25	0.033038	0.80
2F	2. Industrial Proc	F. Consumption of Halocarbons and SF6			HFC	0.00	6.64	0.024557	0.85
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CO2	16.48	12.09	0.017704	0.88
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CO2	0.00	3.27	0.012075	0.91
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	0.12	3.09	0.010967	0.93
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	2.36	3.47	0.003870	0.94
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO2	18.64	18.48	0.002206	0.94
5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO2	2.13	1.70	0.001784	0.94
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	5.45	5.24	0.001290	0.95
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	2.72	2.47	0.001160	0.95
4B	4. Agriculture	B. Manure Management			CH4	2.16	1.98	0.000856	0.95
4A	4. Agriculture	A. Enteric Fermentation			CH4	10.42	10.45	0.000783	0.95
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO2	3.30	3.29	0.000310	0.95
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO2	4.33	4.46	0.000121	0.95
5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland		CO2	0.01	1.69	0.006210	0.96
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CH4	0.32	1.06	0.002715	0.97
5F2	5. LULUCF	F. Other Land	2. Land converted to Other Land		CO2	0.44	1.15	0.002588	0.97
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	0.73	0.22	0.001952	0.98
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	0.54	0.11	0.001637	0.98
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	0.13	0.56	0.001562	0.98
3	3. Solvent and Other Product Use				N2O	0.47	0.25	0.000844	0.99
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	0.22	0.01	0.000777	0.99
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	0.03	0.24	0.000775	0.99
3	3. Solvent and Other Product Use				CO2	0.08	0.27	0.000692	0.99
6D	6. Waste	D. Other			CH4	0.40	0.57	0.000570	0.99
4B	4. Agriculture	B. Manure Management			N2O	1.21	1.36	0.000414	0.99
6B	6. Waste	B. Wastewater Handling			N2O	0.79	0.90	0.000339	0.99
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	0.09	0.00	0.000328	0.99
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	1.30	1.41	0.000302	0.99
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.01	0.09	0.000296	0.99
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	0.14	0.08	0.000251	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.06	0.000231	1.00
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	0.08	0.14	0.000221	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	0.01	0.06	0.000201	1.00
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	0.99	1.06	0.000167	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	0.01	0.06	0.000158	1.00
5A2	5. LULUCF	A. Forest Land	2. Land converted to Forest Land		CO2	0.10	0.07	0.000151	1.00
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		CO2	0.11	0.08	0.000127	1.00
6D	6. Waste	D. Other			N2O	0.08	0.12	0.000118	1.00
5D2	5. LULUCF	D. Wetlands	2. Land converted to Wetlands		CO2	0.16	0.13	0.000111	1.00
6B	6. Waste	B. Wastewater Handling			CH4	0.07	0.10	0.000107	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	0.01	0.04	0.000105	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.00	0.03	0.000105	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	0.02	0.05	0.000104	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	N2O	0.05	0.03	0.000083	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	0.05	0.03	0.000083	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.05	0.08	0.000079	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	0.00	0.02	0.000054	1.00
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	0.03	0.04	0.000047	1.00
5E1	5. LULUCF	E. Settlements	1. Settlements remaining Settlements		CO2	0.05	0.04	0.000046	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CH4	0.04	0.03	0.000041	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	0.02	0.01	0.000030	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.00	0.01	0.000026	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	0.01	0.00	0.000022	1.00
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		N2O	0.00	0.00	0.000018	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	0.01	0.00	0.000017	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	N2O	0.01	0.01	0.000010	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CH4	0.01	0.00	0.000009	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	0.01	0.00	0.000009	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.00	0.000007	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.00	0.00	0.000006	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	0.01	0.02	0.000004	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.00	0.00	0.000003	1.00
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	0.00	0.00	0.000002	1.00
6C	6. Waste	C. Waste Incineration			CO2	0.01	0.01	0.000002	1.00
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.00	0.00	0.000002	1.00
6C	6. Waste	C. Waste Incineration			CH4	0.01	0.01	0.000001	1.00
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	0.00	0.00	0.000001	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	0.00	0.00	0.000000	1.00
6C	6. Waste	C. Waste Incineration			N2O	0.00	0.00	0.000000	1.00
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.00	0.00	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	NO	NO	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	NO	NO	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	NO	NO	0.000000	1.00

(Cont’d next page)

IPCC Source Categories (and fuels if applicable) Trend Assessment					Direct GHG	Base Year 1990 Estimate [Gg CO2eq]	Current Year Estimate [Gg CO2eq]	Trend Assessment	Cumulative Total Col. F-T
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.00	0.00	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.00	0.00	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CH4	0.00	0.00	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	0.00	0.00	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.00	0.00	0.000000	1.00
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	0.00	0.00	0.000000	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CO2	NO	NO	0.000000	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CO2	NO	NO	0.000000	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CH4	0.00	0.00	0.000000	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	CH4	0.00	0.00	0.000000	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CH4	0.00	0.00	0.000000	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	N2O	0.00	0.00	0.000000	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	N2O	0.00	0.00	0.000000	1.00
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	N2O	0.00	0.00	0.000000	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CH4	0.00	0.00	0.000000	1.00
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	N2O	0.00	0.00	0.000000	1.00
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	NO	NO	0.000000	1.00
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CH4	0.00	0.00	0.000000	1.00
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	0.00	0.00	0.000000	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CO2	NO	NO	0.000000	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CH4	0.00	0.00	0.000000	1.00
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	N2O	0.00	0.00	0.000000	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	NO	NO	0.000000	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.00	0.00	0.000000	1.00
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	0.00	0.00	0.000000	1.00
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CO2	NA,NO	NA,NO	0.000000	1.00
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		N2O	NA,NO	NA,NO	0.000000	1.00
2A	2. Industrial Proc	A. Mineral Products			CO2	NO	NO	0.000000	1.00
2A	2. Industrial Proc	A. Mineral Products			CH4	NO	NO	0.000000	1.00
2A	2. Industrial Proc	A. Mineral Products			N2O	NO	NO	0.000000	1.00
2B	2. Industrial Proc	B. Chemical Industry			CO2	NO	NO	0.000000	1.00
2B	2. Industrial Proc	B. Chemical Industry			CH4	NO	NO	0.000000	1.00
2B	2. Industrial Proc	B. Chemical Industry			N2O	NO	NO	0.000000	1.00
2C	2. Industrial Proc	C. Metal Production			CO2	NO	NO	0.000000	1.00
2C	2. Industrial Proc	C. Metal Production			CH4	NO	NO	0.000000	1.00
2C	2. Industrial Proc	C. Metal Production			N2O	NO	NO	0.000000	1.00
2D	2. Industrial Proc	D. Other Production			CO2	NO	NO	0.000000	1.00
2E	2. Industrial Proc	E. Production of Halocarbons and SF6			CO2	0.00	0.00	0.000000	1.00
2F	2. Industrial Proc	F. Consumption of Halocarbons and SF6			PFC	NO	0.07	0.000000	1.00
2F	2. Industrial Proc	F. Consumption of Halocarbons and SF6			SF6	NO	0.02	0.000000	1.00
2F	2. Industrial Proc	F. Consumption of Halocarbons and SF6			CO2	0.00	0.00	0.000000	1.00
2G	2. Industrial Proc	G. Other			CO2	NO	NO	0.000000	1.00
2G	2. Industrial Proc	G. Other			CH4	NO	NO	0.000000	1.00
2G	2. Industrial Proc	G. Other			N2O	NO	NO	0.000000	1.00
4C	4. Agriculture	C. Rice Cultivation			CH4	NA,NO	NA,NO	0.000000	1.00
4D	4. Agriculture	D. Agricultural Soils			CH4	NA,NO	NA,NO	0.000000	1.00
4E	4. Agriculture	E. Prescribed Burning of Savannas			CH4	NA	NA	0.000000	1.00
4E	4. Agriculture	E. Prescribed Burning of Savannas			N2O	NA	NA	0.000000	1.00
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH4	NA,NO	NA,NO	0.000000	1.00
4F	4. Agriculture	F. Field Burning of Agricultural Residues			N2O	NA,NO	NA,NO	0.000000	1.00
4G	4. Agriculture	G. Other			CH4	NA	NA	0.000000	1.00
4G	4. Agriculture	G. Other			N2O	NA	NA	0.000000	1.00
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CH4	0.00	0.00	0.000000	1.00
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		N2O	0.00	0.00	0.000000	1.00
5D1	5. LULUCF	D. Wetlands	1. Wetlands remaining Wetlands		CO2	0.00	0.00	0.000000	1.00
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	NO	NO	0.000000	1.00
6D	6. Waste	D. Other			CO2	NO	NO	0.000000	1.00
TOTAL					*All*	*258.14*	*264.27*		

Table A - 4 Liechtenstein's key categories in 2010 including LULUCF categories (Summary). In accordance with GPG (IPCC 2000) estimates for removals are accounted with a positive sign.

IPCC Source Categories (and fuels if applicable) Source Category Analysis Summary					Direct GHG	Key Source Category Flag	If Column C is Yes, Criteria for Identification
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	yes	Level, Trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CH4	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	no	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	CH4	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	N2O	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CO2	yes	Level, Trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CH4	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	N2O	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CO2	yes	Level, Trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	N2O	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CH4	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CO2	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CH4	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	N2O	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CO2	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CH4	no	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	N2O	no	
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	no	
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	no	
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	no	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	no	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	no	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	yes	Level, Trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	no	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	no	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CO2	yes	Level, Trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CH4	no	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	N2O	no	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	yes	Level, Trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	no	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	no	
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (militar		CO2	no	
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (militar		CH4	no	
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (militar		N2O	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	yes	Level, Trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	yes	Level, Trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CO2	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CH4	no	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	N2O	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	yes	Level, Trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	yes	Level, Trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	no	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	no	
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	no	
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	no	
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	no	
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	no	
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	no	
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	no	

(Cont'd next page)

IPCC Source Categories (and fuels if applicable) Source Category Analysis Summary					Direct GHG	Key Source Category Flag	If Column C is Yes, Criteria for Identification
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	yes	Level
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	no	
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	no	
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CH4	no	
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CO2	no	
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		N2O	no	
2A	2. Industrial Proc.	A. Mineral Products			CO2	no	
2A	2. Industrial Proc.	A. Mineral Products			CH4	no	
2A	2. Industrial Proc.	A. Mineral Products			N2O	no	
2B	2. Industrial Proc.	B. Chemical Industry			CO2	no	
2B	2. Industrial Proc.	B. Chemical Industry			CH4	no	
2B	2. Industrial Proc.	B. Chemical Industry			N2O	no	
2C	2. Industrial Proc.	C. Metal Production			CO2	no	
2C	2. Industrial Proc.	C. Metal Production			CH4	no	
2C	2. Industrial Proc.	C. Metal Production			N2O	no	
2D	2. Industrial Proc.	D. Other Production			CO2	no	
2E	2. Industrial Proc.	E. Production of Haloc			CO2	no	
2F	2. Industrial Proc.	F. Consumption of Hal			HFC	yes	Level, Trend
2F	2. Industrial Proc.	F. Consumption of Hal			PFC	no	
2F	2. Industrial Proc.	F. Consumption of Hal			SF6	no	
2F	2. Industrial Proc.	F. Consumption of Hal			CO2	no	
2G	2. Industrial Proc.	G. Other			CO2	no	
2G	2. Industrial Proc.	G. Other			CH4	no	
2G	2. Industrial Proc.	G. Other			N2O	no	
3	3. Solvent and Othe				N2O	no	
3	3. Solvent and Othe				CO2	no	
4A	4. Agriculture	A. Enteric Fermentatio			CH4	yes	Level
4B	4. Agriculture	B. Manure Manageme			CH4	no	
4B	4. Agriculture	B. Manure Manageme			N2O	no	
4C	4. Agriculture	C. Rice Cultivation			CH4	no	
4D	4. Agriculture	D. Agricultural Soils			CH4	no	
4D_o	4. Agriculture	D. Agricultural Soils wi			N2O	no	
4D1	4. Agriculture	D. Agricultural Soils; D			N2O	yes	Level
4D3	4. Agriculture	D. Agricultural Soils; In			N2O	yes	Level
4E	4. Agriculture	E. Prescribed Burning			CH4	no	
4E	4. Agriculture	E. Prescribed Burning			N2O	no	
4F	4. Agriculture	F. Field Burning of Agr			CH4	no	
4F	4. Agriculture	F. Field Burning of Agr			N2O	no	
4G	4. Agriculture	G. Other			CH4	no	
4G	4. Agriculture	G. Other			N2O	no	
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO2	yes	Level, Trend
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CH4	no	
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		N2O	no	
5A2	5. LULUCF	A. Forest Land	2. Land converted to Forest Land		CO2	no	
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO2	yes	Level
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		CO2	no	
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		N2O	no	
5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO2	yes	Level, Trend
5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland		CO2	no	
5D1	5. LULUCF	D. Wetlands	1. Wetlands remaining Wetlands		CO2	no	
5D2	5. LULUCF	D. Wetlands	2. Land converted to Wetlands		CO2	no	
5E1	5. LULUCF	E. Settlements	1. Settlements remaining Settlements		CO2	no	
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO2	yes	Level
5F2	5. LULUCF	F. Other Land	2. Land converted to Other Land		CO2	no	
6A	6. Waste	A. Solid Waste Dispos			CH4	no	
6A	6. Waste	A. Solid Waste Dispos			CO2	no	
6B	6. Waste	B. Wastewater Handlin			N2O	no	
6B	6. Waste	B. Wastewater Handlin			CH4	no	
6C	6. Waste	C. Waste Incineration			CO2	no	
6C	6. Waste	C. Waste Incineration			CH4	no	
6C	6. Waste	C. Waste Incineration			N2O	no	
6D	6. Waste	D. Other			CH4	no	
6D	6. Waste	D. Other			N2O	no	
6D	6. Waste	D. Other			CO2	no	

Annex 2: Detailed discussion of methodology and data for estimating CO_2 emissions from fossil fuel combustion

CO_2 Emission Factors, net calorific values and densities of fossil fuels

All parameters of fossil fuels are assumed to be constant for the period 1990 to 2010.

Table A - 5 Parameters of fossil fuels used for the modelling of Liechtenstein's GHG emissions. Data source: FOEN 2011.

Fuel	CO2 Emission Factor 1990-2010			Net calorific values (NCV)		Density
	t CO_2 / TJ	t CO_2 / t	t CO_2 / volume	**GJ / t**	**GJ / volume**	**t / volume**
Hard Coal	94.0	2.47	---	26.3	---	---
Gas Oil	73.7	3.14	2.65t / 1000 lt	42.6	36.0 / 1000 lt	0.845 t / 1000 lt
Residual Fuel Oil	77.0	3.17	3.01t / 1000 lt	41.2	39.1 / 1000 lt	0.950 t / 1000 lt
Natural Gas	55.0	2.56	2.00t / 1000 Nm^3	46.5	36.3 / 1000 Nm^3	0.780 t / 1000 Nm^3
Gasoline	73.9	3.14	2.34t / 1000 lt	42.5	31.7 / 1000 lt	0.745 t / 1000 lt
Diesel Oil	73.6	3.15	2.61t / 1000 lt	42.8	35.5 / 1000 lt	0.830 t / 1000 lt
Propane/Butane (LPG)	65.5	---	---	46.0	---	---
Jet Kerosene	73.2	3.15	2.52t / 1000 lt	43.0	34.4 / 1000 lt	0.800 t / 1000 lt
Lignite	104.0	2.09	---	20.1	---	---
Alkylate Gasoline	73.9	3.14	2.34t / 1000 lt	42.5	31.7 / 1000 lt	0.745 t / 1000 lt
Biofuel (vegetable oil)	89.0	3.35	---	37.6	34.6 / 1000 lt	0.92 t / 1000 lt

Annex 3: Other detailed methodological descriptions for individual source or sink categories

A3.1 Additional Data for N_2O Emission Calculation of Agricultural Soils (4D)

Table A - 6 Additional data for N_2O emission calculation of agricultural soils (4D).

2010	Unit	Activity Data
1. Cereals		
Wheat	a	10'997
Barley	a	4'850
Maize	a	4'263
Oats	a	376
Rye	a	0
Other (please specify)		
Triticale	a	1'660
Spelt	a	950
Mix of fodder cereals	a	578
Mix of bread cereals		
2. Pulse		
Dry bean	a	0
peas (Eiweisserbsen)	a	0
Soybeans	a	375
Other (please specify)		
Leguminous vegetables	a	1'400
3. Tuber and Root		
Potatoes	a	7'093
Other (please specify)		
Fodder beet	a	956
Sugar beet	a	2'858
5. Other (please specify)		
Silage corn	a	35'831
Green corn	a	0
Fruit	a	222
Vine	t	106
Non-leguminous vegetables	a	9'481
Sunflowers	a	0
Tobacco	a	0
Rape	a	0
Total Non-leguminous	t	84'713
Total Leguminous	a	1'775
Total	a	86'488

A3.2 Further Information on Land-use change calculation

Table A - 7: Land-use change between 1989 and 1990 (change matrix). Units: ha/year.

				To																																				
				11			12			13			21		31						32			33		34			35		36	37	41	42	51	52	53	54	61	Decrease
	CC-code	altitude zone	soil type	1	2	3	1	2	3	1	2	3	n.s.	n.s.	1	1	2	2	3	3	1	2	3	n.s.	n.s.	1	2	3	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	
				n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0	1	0	1	0	1	0	1	n.s.	n.s.	n.s.	0	1	n.s.	n.s.	n.s.	0	1	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	
From	11	1	n.s.	0	0	0	0.42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4
		2	n.s.	0	0	0	0	1.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1
		3	n.s.	0	0	0	0	0	1.58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6
	12	1	n.s.	0	0	0	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0.08	0	0	0	0	0.08	0	0	0	0	0	0	0.17	0.08	1	0	0.25	0.25	0.08	2.1
		2	n.s.	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0.33	0.17	0.08	0	0.17	1.2
		3	n.s.	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0.08	0	0	0	0.08	0	0	0	0	0	0	0	0.8
	13	1	n.s.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
		2	n.s.	0	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
		3	n.s.	0	0	0.5	0	0	1.33	0	0	0	0	0	0	0	0	0	0.42	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	2.5
	21	n.s.	0	0	0	0	0	0	0	0	0	0	0	0	2.75	0	0	0	0	0	0	0	0	0.17	0	0.42	0	0	0	0	0	0	0	0	3.25	0.92	0.08	0.17	0	7.8
		n.s.	1	0	0	0	0	0	0	0	0	0	0	0	0	0.42	0	0	0	0	0	0	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
	31	1	0	0.08	0	0	0	0	0	0	0	0	2.75	0	0	0	0	0	0	0	0.17	0	0	0.33	0	2.58	0	0	0	0	0	0	0	0	4.42	2.75	0	0.25	0.08	13.4
		1	1	0	0	0	0	0	0	0	0	0	0	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.42	0	0	0	0	0	0.8
		2	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0	0	0.67	0	0	0	0	0	0	0	0.83	0.75	0	0.08	0.08	2.6
		2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
		3	0	0	0	0.75	0	0	0.17	0	0	1.75	0	0	0	0	0	0	0	0	0	0	1.75	0	0	0	0	0.42	0	0	0.08	0	0	0	0.5	0.08	0	0	0.25	5.8
		3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	32	1	n.s.	0	0	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0.08	0	0	0	0.08	0	0	0	1.1
		2	n.s.	0	0	0	0	0.42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0.6
		3	n.s.	0	0	0.17	0	0	2.92	0	0	4.67	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	10.3
	33	n.s.	0	0	0	0	0	0	0	0	0	0	0.17	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0	0	0	0	0.5
		n.s.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	34	1	n.s.	0.08	0	0	0.58	0	0	0	0	0	0.08	0	2.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.42	0.83	0	0.33	0	5.7
		2	n.s.	0	0	0	0	0.42	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0.08	0	0	0	0.17	0	0	0	0	1.3
		3	n.s.	0	0	0.17	0	0	1.25	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5
	35	n.s.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
		n.s.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	36	n.s.	n.s.	0	0	0.33	0	0	0.08	0	0	0.08	0	0	0	0	0	0	0.33	0	0.25	0	0.25	0.08	0	0	0	0.08	0	0	0	0.25	0	0	0	0	0	0	0.33	2.1
	37	n.s.	n.s.	0	0	0.17	0.17	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0.25	0	0.92	0	0	0.5	0	0.08	0	0	0.08	0	0	0	0.08	0	0	0	0	2.4
	41	n.s.	n.s.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0	0	0	3.42	3.6
	42	n.s.	n.s.	0.17	0	0	0.25	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
	51	n.s.	n.s.	0.58	0	0	0	0	0	0	0	0	0	0	0.33	0	0.08	0	0	0	0.17	0	0	0	0	0.17	0	0	0	0	0	0	0	0.08	0	0.75	0.08	0	0	2.2
	52	n.s.	n.s.	0	0	0	0	0	0	0	0	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5	0	0.17	2.5	0	5.3
	53	n.s.	n.s.	0.08	0	0	0.17	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0	0	0	0	0	0	0	0.25	0.08	0	0.5	0.08	1.3
	54	n.s.	n.s.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.42	0.75	0	0	0	1.2
	61	n.s.	n.s.	0	0	0	0.17	0	0	0	0	0	0	0	0.17	0	0	0	0.08	0	0.25	0.17	0.08	0.08	0	0	0	0	0	0	0.58	0.08	0.33	0.08	0	0	0	0	0	2.1
	Increase			1.0	0.1	2.1	2.5	2.1	7.4	0.1	0.2	7.3	3.0	0.3	5.9	0.4	0.7	0.0	2.3	0.0	1.3	0.3	3.3	0.7	0.0	4.1	0.9	1.7	0.0	0.0	1.0	0.5	0.5	0.7	15.3	7.2	0.7	4.1	4.7	82.2

Table A - 8: Land-use change between 1999 and 2000 (change matrix). Units: ha/year.

				To																																				
				11			12			13			21		31						32			33		34			35		36	37	41	42	51	52	53	54	61	Decrease
	CC-code	altitude zone	soil type	1	2	3	1	2	3	1	2	3	n.s.	n.s.	1	1	2	2	3	3	1	2	3	n.s.	n.s.	1	2	3	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	
				n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0	1	0	1	0	1	0	1	n.s.	n.s.	n.s.	0	1	n.s.	n.s.	n.s.	0	1	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	
From	11	1	n.s.	0	0	0	1.83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.8
		2	n.s.	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
		3	n.s.	0	0	0	0	0	3.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.7
	12	1	n.s.	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0.17	0	0	0	0	0.17	0	0	0	0	0	0.17	0	0	1.83	0.17	0.33	0.17	0	3.2
		2	n.s.	0	0	0	0	0	0	0	0.83	0	0	0	0	0	0	0	0	0	0	0.33	0	0	0	0	0.33	0	0	0	0.33	0	0.33	0	0.17	0.17	0	0	0.67	3.2
		3	n.s.	0	0	0	0	0	0	0	0	1.83	0	0	0	0	0	0	1.17	0	0	0	1.83	0	0	0	0	1.33	0	0	0.33	0.17	0.17	0	0	0	0	0	0.83	7.7
	13	1	n.s.	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
		2	n.s.	0	0	0	0	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0.5
		3	n.s.	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2.5	0	0	0	0.17	0	0	0	0	0	0	0	0.33	0	0	0	0	0	0	0	0	5.0
	21	n.s.	0	0	0	0	0	0	0	0	0	0	0	0	8.33	0	0	0	0	0	0.17	0	0	0.67	0	0	0	0	0	0	0.33	0	0.17	0.33	2.67	0.67	0.17	0	0.33	13.8
		n.s.	1	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
	31	1	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0.33	0	0	0.33	0	2.17	0	0	0	0	0.17	0.17	0	0.33	4.17	1.83	0.17	0	0.5	16.2
		1	1	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0.17	0.5
		2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0.33	0	0	0	0	0	0	0	1	0.67	0	0	0	2.2
		2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
		3	0	0	0	0	0	0	0	0	0	1.33	0	0	0	0	0	0	0	0	0	0	1.83	0	0	0	0	0.17	0	0	1.83	0	0	0	0.17	0.17	0	0	0.67	6.2
		3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	32	1	n.s.	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0.33	0	0	0	0	0	0	0	0	0	0	0.17	0	0	1.2
		2	n.s.	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33	0.7
		3	n.s.	0	0	0.17	0	0	3.17	0	0	3.67	0	0	0	0	0	0	1.33	0	0	0	0	0	0	0	0	0.33	0	0	0.5	0	0	0	0	0	0	0	0.33	9.5
	33	n.s.	0	0	0	0	0	0	0	0	0	0	0.5	0	0.33	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0
		n.s.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	34	1	n.s.	0	0	0	0.17	0	0	0	0	0	0.5	0	4.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.17	1	0	1	0	9.2
		2	n.s.	0	0.17	0	0	0.33	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0.17	0	0.33	0	0	0	0.17	1.8
		3	n.s.	0	0	0	0	0	1.83	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0.17	3.2
	35	n.s.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
		n.s.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	36	n.s.	n.s.	0	0.33	0.17	0	0	0	0	0	0	0	0	0	0	0.17	0	0.5	0	0.67	0	2	0	0	0	0	0	0	0	0	0.67	0	0	0	0	0	0	0.33	4.8
	37	n.s.	n.s.	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0.33	0	0.33	0	1	0	0	0	0.17	0.17	0	0	0.5	0	0	0	0.33	0	0	0	0.33	3.3
	41	n.s.	n.s.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0.33	0	0	0	0.83	1.3
	42	n.s.	n.s.	0	0	0	0.17	0	0	0	0	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
	51	n.s.	n.s.	0.17	0	0	0	0	0	0	0	0	0.17	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	2	0.5	0	0	3.2
	52	n.s.	n.s.	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.33	0	0.67	2.67	0	6.8
	53	n.s.	n.s.	0.17	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33	0.17	0	0.17	0	1.0
	54	n.s.	n.s.	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.83	2.67	0.17	0	0	4.8
	61	n.s.	n.s.	0	0	0	0	0.17	0	0	0	0	0	0	0.17	0	0.17	0	0.33	0	0	0.17	0.33	0	0	0	0	0.17	0	0	1.67	0.17	6.5	0	0	0	0	0	0	9.8
	Increase			0.5	0.5	0.5	3.0	1.2	10.2	0.0	0.8	7.7	7.2	0.2	13.7	0.5	1.0	0.0	6.2	0.0	1.7	0.8	7.8	1.2	0.0	2.8	0.8	2.2	0.0	0.0	6.2	2.0	7.5	0.8	18.7	9.5	2.2	4.0	5.7	126.8

Annex 4: CO_2 Reference Approach and comparison with Sectoral Approach, and relevant information on the national energy balance

No supplementary information to the statements given in Chapter 3.2.1 Comparison of Sectoral Approach with reference Approach.

Annex 5: Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded

No supplementary information to the statements given in Chapter 1.8 Completeness Assessment

Annex 6: Additional information to be considered as part of the NIR submission (where relevant) or other useful reference information

No supplementary information.

Annex 7: Supplementary Information to the Uncertainty Analysis Tier 2

A7.1 Monte Carlo simulations for Liechtenstein's GHG inventory

A Tier 2 uncertainty analysis for Liechtensteins GHG Inventory was carried out for the inventory submitted in 2009 (OEP 2009a) and contained a level uncertainty for 2007 and a trend uncertainty for the period 1990-2007. The Monte Carlo simulation will be repeated in a subsequent year, but was neither carried out for 2008, 2009 nor for the current inventory year 2010. The results shown below may therefore not be compared with the Tier 1 uncertainty results for 2010 given in the Section 1.7.1.3.

The principle of Monte Carlo analysis is to select random values for emission factor and activity data from within their individual probability distributions, and to calculate the corresponding emission values. This procedure is repeated until an adequately stable result has been found. The results of all iterations yield the overall emission probability distribution.

In the analysis carried out for the GHG inventory 2007, Monte Carlo simulations were performed to estimate uncertainties both in emissions and in emission trends, at the source category level as well as for the inventory as a whole (excluding LULUCF). The simulations were run with the commercial software package Crystal Ball (® Decisioneering). This tool generates random numbers within user-defined probability ranges and probability distributions. As a result, selected statistics are produced for the forecast variables.

A7.2 Monte Carlo results for the GHG inventory 2007

a) Uncertainty in emissions

As a first step, for key categories, the shape and extent of the probability distributions were derived for the activity data and emission factors, based on measured data, literature or expert judgement. The mean value of the probability distributions was set equal to the value of the GHG inventory. In most cases, normal distributions were assumed. However, for two key categories with a high level of uncertainty (4D1 agricultural soils, direct emissions N_2O and 4D3 agricultural soils, indirect emissions N_2O), normal distribution would allow negative emissions. For these cases, log-normal distributions were used. The log-normal distribution is positively skewed and produces only positive values, while the upper bound of emissions may be poorly known.

As a second step, emissions were calculated as emission factor multiplied by the corresponding activity data. For those cases where the activity data or emission factor for a specific source category were not available as well as for all non key categories, emissions were modelled directly, with the mean value set equal to the value of the GHG inventory and an adequate probability distribution of the emissions.

The Monte Carlo simulation then provided information on the simulated distribution, on the 2.5 and 97.5 percentiles of emissions, on the uncertainty of the national total emission in 2007 and in the base year 1990 as well as on the trend uncertainty 1990–2007.

b) Dependent Uncertainties

Correlations may have a significant effect on the overall inventory uncertainty. The more the source categories are differentiated the more correlations become important. For the Liechtenstein inventory, the differentiation is on a relatively low level: The most important energy sector is only split into fuel types for the purpose of Monte Carlo simulation but not into source categories. Therefore only correlations between the fuel types have to be considered for the level uncertainty, especially correlations between gasoline and diesel consumption. A detailed description of the assumptions for the present analysis and the respective correlation coefficients can be found in Annex A7. For consistency reasons, Crystal Ball software adjusted a few of the correlation coefficients by an average of 0.10.

c) Uncertainty in Emission Trends

The trend is defined as the difference between the base year and the year of interest (year t, 2007). Hence for estimation of the uncertainty in the emission trends, the Monte Carlo simulation was run for the year 2007 and for the base year 1990. The trend was then derived for the source categories as well as for the total emissions. It was assumed that

- the uncertainties for the base year are equal to the uncertainties of 2007 and that the probability distributions of the 1990 data are of equal shape as the distributions derived for 2007,
- the activity data of 1990 are positively correlated with the activity data of 2007 (correlation coefficients are set to 0.5)
- and that the emission factors of the two years are assumed to be positively correlated with correlation coefficient set to 1.0.

For a more sophisticated analysis, the uncertainties of the base year will have to be considered more closely and set larger for a couple of activity data. This improvement will have to be realised for a later submission.

d) Results

Uncertainties of national total 2007 and of trend 1990–2007

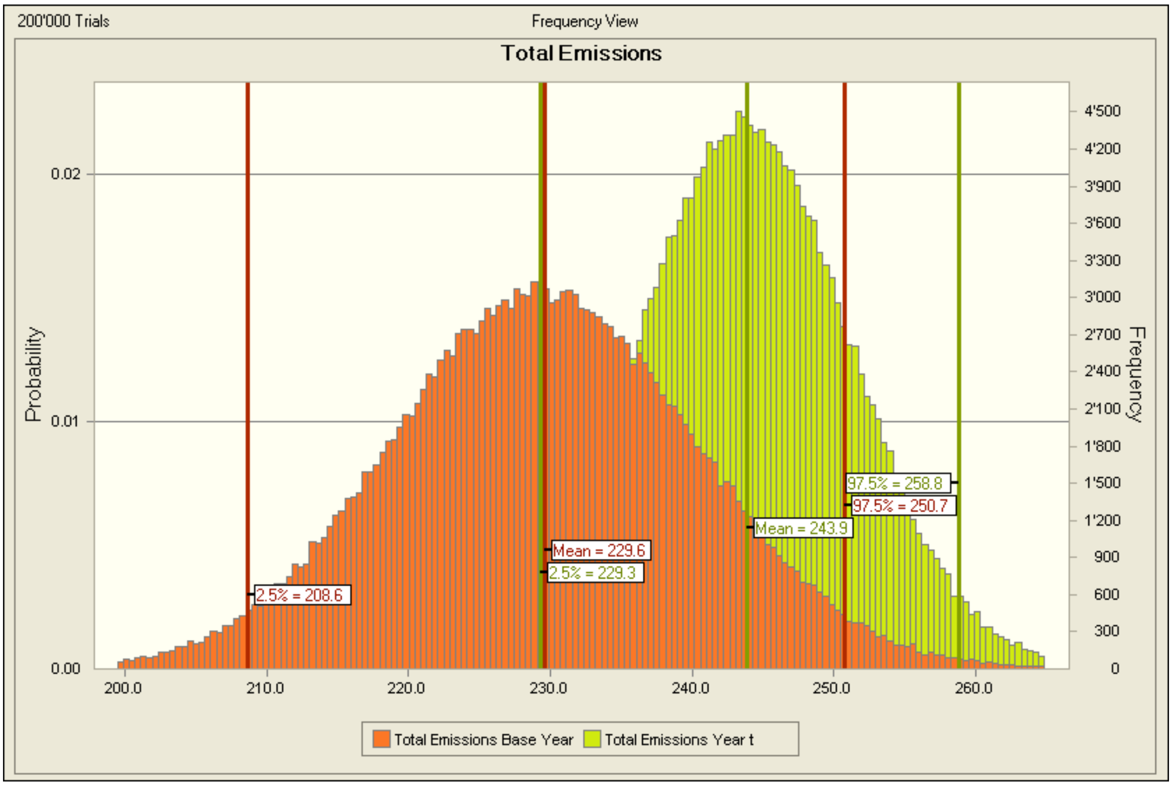

Figure A-1 Probability distributions of total emissions for the base year 1990 (in red) and year t=2007 (in green). On the x-axis, the total emissions reported in the inventory (excl. LULUCF) are given in Gg CO_2 eq. The number of Monte Carlo runs is 200’000. The vertical lines show simulated mean values (*Mean*) and the *2.5%* and *97.5%* percentile values.

Main results of the Monte Carlo simulation

Level uncertainty of national total emissions in 2007

The total uncertainty of the 2007 Liechtenstein emissions is **6,05%** (14.7 Gg CO_2 equivalent) of the total GHG emissions (243.5 Gg CO_2 equivalent excluding LULUCF).

The 95% confidence interval is almost symmetric and lies between **94.0% and 106.1%** of the Liechtenstgein total GHG emissions. The end points are: 229.0 Gg (=243.5 Gg–14.5 Gg) and 258.4 Gg (=243.5 Gg+15.0 Gg).

Trend uncertainty of national total emissions 1990–2007

The change in total emissions between 1990 and 2007 is +6.1%. With a probability of 95%, the change lies within the range **of -2.7% to +15.0%, corresponding to a trend uncertainty of 8.9%.**

The uncertainty analysis presented in this paragraph is based on the data of the GHG inventory for 1990 and 2007 as previously submitted in March 2009. The Monte Carlo Simulation includes all emission source categories, i.e. key categories **and** non-key categories. However, both groups were treated slightly differently for the simulation:

Key categories: For the category 1A Energy Fuel Combustion, the uncertainties of both activity data and emission factors are taken into account for the simulation. For the remaining key categories, only the uncertainty of the emissions is taken into consideration.

Table A - 9: Tier 2 uncertainty results for sources in Liechtenstein 2007 (IPCC 2000, Table 6.2). In this table, uncertainties of the key categories are reported. For the non-key categories, see Table A - 11.

A				B	C	D	E	F	G	H	I	J
IPPC Source Category				Gas	Base year (1990) emissions	Year t (2006) emissions	Uncertainty in year t emissions as % of emissions in the category		Uncertainty introduced on national total in year t	% change in emissions between year t and base year	Range of likely % change between year t and base year	
					(Gg CO2 equivalent)	(Gg CO2 equivalent)	% below (2.5 percentile)	% above (97.5 percentile)	(%)	(%)	% below (2.5 percentile)	% above (97.5 percentile)
1. CO2 emissions from Fuel Combustion												
1A	1. Energy	A. Fuel Combustion	Gaseous fuels	CO2	27.8	76.9	93	107	2.1	177	163	191
1A	1. Energy	A. Fuel Combustion	Gas oil and LPG	CO2	94.6	45.6	80	120	3.7	-52	-69	-35
1A	1. Energy	A. Fuel Combustion	Gasoline	CO2	60.5	55.8	90	110	2.3	-8	-17	2
1A	1. Energy	A. Fuel Combustion	Diesel	CO2	18.4	31.9	85	115	1.9	73	51	95
1A	1. Energy	A. Fuel Combustion	Jet Kerosene	CO2	0.08	0.13	85	115	0.0	77	55	100
1A	1. Energy	A. Fuel Combustion	Solid fuels	CO2	0.09	0.01	80	120	0.0	-86	-105	-68
2. Emissions which are not CO2 emissions from Fuel Combustion												
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6		HFC	0.00	4.5	86	114	0.2	53'245'125	46'017'556	60'445'379
4A	4. Agriculture	A. Enteric Fermentation		CH4	9.8	10.4	82	118	0.8	6	-20	32
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions		N2O	5.8	5.7	25	175	1.7	-2	-110	107
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		N2O	2.7	2.5	100	256	1.3	-8	-234	207
Other					9.7	10.0	*	*	*	*	*	*
Total					229.6	243.5	94.0	106.1	6.05	6.01	-2.7	15.0

Table A-12 shows uncertainty results in a symmetrised form for the of the key categories. The uncertainty of the emission is only a Monte-Carlo simulated result for 1A sourc categories. For the other categories, the uncertainty of the emission is an input data for the Monte Carlo simulation.

Table A - 10 Activity data 2007, emission factors 2007, emissions 2007 and their corresponding uncertainties of key categories in Monte Carlo simulation see Table A -13

IPCC Source category			Gas	Activity Data Year t (2007)		Uncertainty of Activity Data	Emission Factor		Uncertainty of Emission Factor	Emissions Year t	Uncertainty of
						(%)			(%)	Gg CO_2 equivalent)	(%)
1. CO2 emissions from Fuel Combustion											
1A	1. Energy	Gaseous fuels	CO2	1399	(TJ)	5.0	55.0	(t/TJ)	4.6	77	6.8
1A	1. Energy	Gas oil and LPG	CO2	619	(TJ)	20.0	73.6	(t/TJ)	0.6	46	20.0
1A	1. Energy	Gasoline	CO2	756	(TJ)	10.0	73.9	(t/TJ)	1.4	56	10.1
1A	1. Energy	Diesel	CO2	434	(TJ)	15.0	73.6	(t/TJ)	0.5	32	15.0
1A	1. Energy	Jet Kerosene	CO2	1.8	(TJ)	15.0	73.2	(t/TJ)	1.2	0.1	15.0
1A	1. Energy	Solid fuels	CO2	0.13	(TJ)	20.0	94.0	(t/TJ)	5.0	0.01	20.6
2. Emissions which are not CO2 emissions from Fuel Combustion											
2F	F. Consumption of Halocarbons and SF6		HFC	---	---	---	---	---	---	4.47	6.9
4A	A. Enteric Fermentation		CH4	---	---	---	---	---	---	10.38	9.2
4D1	D. Agricultural Soils; Direct Soil Emissions		N2O	---	---	---	---	---	---	5.66	38.3
4D3	D. Agricultural Soils; Indirect Emissions		N2O	---	---	---	---	---	---	2.51	79.6

Table A - 11 shows the results of the Tier 2 uncertainty calculation for all emission source categories, including non-key categories. The lower and the upper limit of the 95% confidence interval is given for each category, as well as the uncertainty introduced on the national total in year t (2007).

Table A - 11 Tier 2 Uncertainty calculation and reporting for all sources, including non-key categories.

A					B	C	D	E	F	G
IPCC Source category					Gas	Base Year Emissions (1990)	Year t Emissions (2007)	Uncertainty in Year t emissions as % of emissions in the category		Uncertainty introduced on national total in Year t
								% below (2.5 percentile)	% upper (97.5 percentile)	%
KEY SOURCES										
1. CO2 emissions from Fuel Combustion										
1A	1. Energy	A. Fuel Combustion		Gaseous fuels	CO2	27.8	76.9	71.9	82.1	2.1
1A	1. Energy	A. Fuel Combustion		Gas oil and LPG	CO2	94.6	45.6	36.6	54.5	3.7
1A	1. Energy	A. Fuel Combustion		Gasoline	CO2	60.5	55.8	50.3	61.4	2.3
1A	1. Energy	A. Fuel Combustion		Diesel	CO2	18.4	31.9	27.2	36.6	1.9
1A	1. Energy	A. Fuel Combustion		Jet Kerosene	CO2	0.08	0.13	0.1	0.2	0.01
1A	1. Energy	A. Fuel Combustion		Solid fuels	CO2	0.09	0.01	0.0	0.0	0.001
2. Emissions which are not CO2 emissions from Fuel Combustion										
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			HFC	0.00	4.5	3.9	5.1	0.2
4A	4. Agriculture	A. Enteric Fermentation			CH4	9.8	10.4	8.5	12.2	0.8
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	5.8	5.7	1.4	9.9	1.7
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	2.7	2.5	0.0	6.4	1.3
NON KEY SOURCES										
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			SF6	NO	0.12	0.1	0.1	0.0
3	3. Solvent and Other Product Use				CO2	1.5	0.86	0.2	1.5	0.3
6C	6. Waste	C. Waste Incineration			CO2	0.01	0.01	0.0	0.0	0.0
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.001	0.02	0.0	0.0	0.0
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.002	0.00	0.0	0.0	0.0
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructio	Gaseous Fuels	CH4	0.04	0.05	0.0	0.1	0.0
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructio	Liquid Fuels	CH4	0.01	0.00	0.0	0.0	0.0
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.00	0.00	0.0	0.0	0.0
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	0.01	0.01	0.0	0.0	0.0
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	0.49	0.10	0.0	0.2	0.0
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CH4	0.00	0.05	0.0	0.1	0.0
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.00	0.0	0.0	0.0
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	0.02	0.06	0.0	0.1	0.0
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	0.02	0.01	0.0	0.0	0.0
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	0.00	0.01	0.0	0.0	0.0
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	0.01	0.05	0.0	0.1	0.0
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	0.01	0.00	0.0	0.0	0.0
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	0.01	0.00	0.0	0.0	0.0
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	0.13	0.42	0.3	0.5	0.1
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	0.00	0.00	0.0	0.0	0.0
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	0.00	0.00	0.0	0.0	0.0
1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		CH4	0.32	1.07	0.0	1.6	0.2

(cont'd next page)

4B	4. Agriculture	B. Manure Management			CH4	1.9	1.7	0.8	2.7	0.4
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	0.22	0.02	0.0	0.0	0.0
6B	6. Waste	B. Wastewater Handling			CH4	0.02	0.03	0.0	0.0	0.0
6C	6. Waste	C. Waste Incineration			CH4	0.01	0.01	0.0	0.0	0.0
6D	6. Waste	D. Other			CH4	0.40	0.66	0.3	1.0	0.2
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.00	0.00	0.0	0.0	0.0
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.05	0.08	0.0	0.1	0.0
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructio	Gaseous Fuels	N2O	0.01	0.01	0.0	0.0	0.0
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructio	Liquid Fuels	N2O	0.05	0.02	0.0	0.0	0.0
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	0.00	0.00	0.0	0.0	0.0
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	0.05	0.16	0.0	0.4	0.1
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	0.47	0.48	0.0	1.2	0.2
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	N2O	0.00	0.00	0.0	0.0	0.0
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.00	0.0	0.0	0.0
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.00	0.02	0.0	0.0	0.0
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	0.14	0.07	0.0	0.1	0.0
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	0.01	0.04	0.0	0.1	0.0
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.01	0.08	0.0	0.1	0.0
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	0.05	0.02	0.0	0.0	0.0
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.00	0.00	0.0	0.0	0.0
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	0.01	0.03	0.0	0.1	0.0
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	0.01	0.02	0.0	0.0	0.0
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	0.03	0.04	0.0	0.1	0.0
3	3. Solvent and Other Product Use				N2O	0.47	0.25	0.1	0.4	0.1
4B	4. Agriculture	B. Manure Management			N2O	1.5	1.6	0.7	2.5	0.4
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	0.82	0.66	0.1	1.2	0.2
6B	6. Waste	B. Wastewater Handling			N2O	0.81	0.99	0.0	2.5	0.5
6C	6. Waste	C. Waste Incineration			N2O	0.00	0.00	0.0	0.0	0.0
6D	6. Waste	D. Other			N2O	0.08	0.14	0.0	0.3	0.1
Total						229.6	243.5	229.0	258.4	6.05

d) Comparison of Tier 1 with Tier 2 results

In the GHG inventory, some of the uncertainties may become large and their statistical distribution may clearly deviate from normal distributions. Tier 1 uncertainty analysis is based on simple error propagation, which assumes only small and normally distributed uncertainties. The application of the Tier 1 method is therefore not the optimal instrument for determining the uncertainties of a GHG inventory. The more appropriate choice is the Monte Carlo simulation, which is designed for uncertainties of any shape, for any size of uncertainties, any correlated figures and which is recommended by the IPCC Good Practice Guidance (IPCC 2000) as the Tier 2 method. The results of the Monte Carlo simulation are therefore considered to provide a more realistic picture of the uncertainties than the results of the Tier 1 method.

Tier 2 uncertainty analysis produces an overall level uncertainty of 6.05% for 2007 emissions. This value is somewhat larger then the result of Tier 1 uncertainty analysis for 2007 (5.95%). The correct treating of large uncertainties, the existence of correlations and the lognormal distributions for agricultural sources do all together increase the uncertainty slightly.

The trend uncertainty of Tier 2 analysis is 8.9% and is therefore somewhat larger than in Tier 1 analysis, 7.7% (both values hold for 2007). Although the positive correlations for activity data and emission factors between of the base year and the year 2007 tend to lower the trend uncertainty (as may be seen from equation A1.8 of IPCC Good Practice Guidance IPCC 2000 with $r > 0$), Tier 2 trend uncertainty is nevertheless larger than Tier 1 trend uncertainty. This may be explained by the methodological differences between Tier 1 and Tier 2 uncertainty analysis. Due to IPCC (2000), chapter 6.3, Tier 1 analysis uses Type A and Type B sensitivity to calculate the trend uncertainty, whereas Tier 2 simulates simple differences between the base year and year t but accounting for correlations between activity data and emission factors.

A7.3 Further assumptions for Monte Carlo simulation (GHG inventory 2007)

a) Assumptions for probability distribution

Table A - 12 Probability distribution assigned to activity data, emission factors and emissions (1990 and 2007) of key categories. For the remaining categories, normal probability distributions have been assigned to the emission uncertainties.

IPCC Source Category		Fuel	Gas	Probability distribution		
				AD	EF	Emission
1. CO2 emissions from Fuel Combustion						
1A	1. Energy	Gaseous fuels	CO2	normal	normal	---
1A	1. Energy	Gas oil and LPG	CO2	normal	normal	---
1A	1. Energy	Gasoline	CO2	normal	normal	---
1A	1. Energy	Diesel	CO2	normal	normal	---
1A	1. Energy	Jet Kerosene	CO2	normal	normal	---
1A	1. Energy	Solid fuels	CO2	normal	normal	---
2. Emissions which are not CO2 emissions from Fuel Combustion						
2F	F. Consumption of Halocarbons and SF6		HFC	---	---	normal
4A	A. Enteric Fermentation		CH4	---	---	normal
4D1	D. Agricultural Soils; Direct Soil Emissions		N2O	---	---	lognormal
4D3	D. Agricultural Soils; Indirect Emissions		N2O	---	---	lognormal

b) Assumptions for correlations between activity data and emissions factors

For modelling of the **level uncertainty**, the following assumption has been made:

- the activity data of categories “1A Fuel combustion, gasoline” and “1A Fuel combustion, diesel” are positively correlated (r = 0.3). As gasoline and diesel sales are always accounted together (questionary filled by sellers), accounting uncertainty is expected to affect both fuels in the same way: either both are underestimated or both are overestimated (positive correlation).

For modelling of the **trend uncertainty,** the following assumptions have been made:

- the emission factors of each source are strongly and positively correlated (r = 1.0) between 1990 and 2007.
- also, the activity data of each source is positively correlated between 1990 and 2007 (r = 0.5). The correlation is not too strong since the methods for documenting the amounts of fuels sold have been changed at last for gasoline and diesel.

c) Relation between simulated and inventory values

The Monte Carlo simulation simulates a probability distribution for which all relevant statistical parameters are determined like mean, standard deviation and percentiles. The simulated mean value may slightly differ from the reported CRF value. This occurs because lognormal distributions are applied to some categories.

The discrepancy between simulated and reported values becomes apparent when mean numbers in Figure A-1 are compared to mean numbers in the CRF tables. Note that it is not a relevant issue for the uncertainty analysis but is rather confusing for readers and reviewers who carefully study the numbers. For transparency reasons, the numbers are explained in Table A - 13.

The absolute percentiles generated by the simulation are expressed as relative numbers (the simulated mean is set to 100%). The relative numbers are then transferred – unchanged – to the mean numbers as reported in the CRF tables, and they are applied to derive the absolute uncertainties (see).

Table A - 13 Mean values, 2.5% and 97.5% percentiles of the Monte Carlo simulation and corresponding values of the CRF emissions.

Parmeters	Unit	Emission (excl. LULUCF)	Lower bound 2.5 percentile	Upper bound 97.5 percentile	Lower uncertainty	Upper uncertainty
simulated values				1990		
absolute	Gg CO_2 eq	229.6	208.6	250.7	-21.0	21.2
relative	%	100.0%	90.9%	109.2%	-9.1%	9.2%
values of CRF						
absolute	Gg CO_2 eq	229.6	208.6	250.7	-21.0	21.2
relative	%	100.0%	90.9%	109.2%	-9.1%	9.2%
simulated values				2007		
absolute	Gg CO_2 eq	243.9	229.3	258.8	-14.5	15.0
relative	%	100.0%	94.0%	106.1%	-6.0%	6.1%
values of CRF						
absolute	Gg CO_2 eq	243.5	229.0	258.4	-14.5	15.0
relative	%	100.0%	94.0%	106.1%	-6.0%	6.1%

Annex 8: Supplementary Information the QA/QC System

A8.1 Checklists for QC activities

- Checklist for project manager (PM), project manager assistant (PMA), staff member climate unit (SC), sectoral experts (SE)
- Checklist for national inventory compiler (NIC)
- Checklist for NIR authors (NA)

Table A - 14 Checklist for QC activities and for follow-up activities if necessary. The general activities are taken from IPCC GPG, table 8.1, the country specific activities are ad-hoc activities of Good Practice Guidance (IPCC 2000). Abbr.: NA NIR authors, NIC national inventory compiler, PM project manager, PMA project manager assistant, DFP designated focal point, SC staff member climate unit, SE sectoral experts. Member codes: AG Andreas Gstoehl, HE Hanspeter Eberle, HK Helmut Kindle, JB Jürgen Beckbissinger, JH Juerg Heldstab, SK Stefan Kessler, FL Fabio Leippert, MH Martin Herren, PI Patrick Insinna, DEF Denise Fussen, CHS Christine Seyler, Sven Braden, SO Markus Sommerhalder.

Liechtenstein **Submission April 2012**				
Checklist for sectoral experts and NIR Authors				
Contact person:	Jürg Heldstab (INFRAS)			
Telephone, e-mail:	+41 44 205 95 11, juerg.heldstab@infras.ch			
QC activity	**Procedure (description of checks that were carried out)**	**respon-sibles**	**date**	**visa**
General activities (table 8.1 IPCC GPG)	***General procedures***			
1. Check that assumptions and criteria for the selection of activity data and emission factors are documented	Acontec-internal checks, comparison with methods chosen	SE/NIC	Aug - Nov 2012	JB
	EBP-internal checks, comparison with methods chosen	NA	06.01.12	
	INFRAS-internal checks, comparison with methods chosen	NA	07.01.12	
2. Check for transcription errors in data input and reference	plausibility check of the basic input data for Solvent and Ind calculation	SE	010.10.11	JB
	plausibility check of the basic input data from the LWA	SE	30.11.11	
	check input Data for SF6 Emission calculation	SE	11.10.11	JB
	check stationary Energy	NA	25.11.11	DEF
	check stationary Ind. Proc., Solvents	NA	22.12.11	CHS
	Check Reference Approach: Some errors identified and corrected in cooperation with Acontec	NA	04.02.12	JH
	check Waste	NA	22.12.11	WOM
	Agriculture: Plausibility check of data in background tables Acontec. Several issues were identified and discussed with Acontec, improvments in documentation was disucussed	SE	Nov/Dec	FL
3. Check that emissions are calculated correctly	Ongoing checks of the calculated emissions in all sectors	SE	Oct - Dec	SE
	Clarification of data/figures with JB, JH and FL	PM	Jan-Feb 2011	PI
	Clarification of comprehension questions with HE and JB	PMA	23.10.07	AG
	EBP-internal control: Plausibility checks, "Delta-Analysis" combined with KCA, INFRAS-internal control of time series, comparison with February 09 submission.	NA	22.12.11	CHS, SO
	INFRAS-internal checks during generationof tables/figure in Chapter. 2 Trends (independant control by second person Juerg Heldstab)	SE	03.01.12	MH
4. Check that parameter and emission units are correctly recorded and that appropriate conversion factors are used	check energy-activity-data (reference approach)	SE	11.11.11	JB
	check input data in the sector Ind. and Solvent	SE	14.11.11	JB
	check Energy	SE	03.01.12	MH
	check Waste	SE	08.11.11	JB
	check Agriculture	SE	06.01.12	FL
	check LULUCF	SE	12.01.12	FL
	check stationary Energy	NA	22.12.11	DEF
	check stationary Ind. Proc., Solvents	NA	22.12.11	CHS
	check Waste	NA	22.12.11	WOM
	check mobile Energy	SE	03.01.12	MH
	check Agriculture	SE	06.01.12	FL
	check LULUCF	SE	12.01.12	FL
5. Check the integrity of database files	integrity checked	SE	Nov. 2011	JB
6. Check for consistency in data between source categories	consistency checked		Sept - Okt 2011	JB
	check stationary Energy	NA	22.12.11	DEF
	check stationary Ind. Proc., Solvents	NA	22.12.11	CHS
	check Waste	NA	22.12.11	WOM
	check mobile Energy	SE	03.01.12	MH
	check Agriculture	SE	10.02.12	FL
	check LULUCF	SE	09.01.12	FL
7. Check that the movement of inventory data among processing steps is correct	Processing checked	NIC	Okt - Nov 2011	JB
	Data transfer from the land-use statistics to the LULUCF tables and clarification of comprehensive questions with JB / FL	SE	01.11.11	HE
	check Agriculture	SE	10.02.12	FL
	plausibility check / control of overall emissions from agriculture in CO2 equivalents, in total and for the source categories for all years	SE	17.01.12	FL
	check LULUCF	SE	09.01.12	FL
8. Check that uncertainties in emissions and removals are estimated or calculated correctly	check stationary Energy	NA	12.12.11	DEF
	check stationary Ind. Proc., Solvents	NA	22.12.11	CHS
	check stationary Waste	NA	22.12.11	WOM
	check mobile Energy, Agriculture	SE	10.02.12	FL
	check the correctness of data extrapolation in the LULUCF sector, based on the available land use inventories and the LFI	SE	09.01.12	FL
9. Undertake review of internal documentation	internal documentation checked	SE	15.02.12	JB
	Internal OEP check of documentation; Clarification of open questions with SE	PM/PMA	16.11.11	PI
	proofread energy section	NA	22.12.11	CHS
	proofread Ind. Proc., Solvents section	NA	06.01.12	DEF
	proofread waste section	NA	08.01.11	SO
	proofread parts of the NIR	SE	January 12	JB
	proofread NIR	NA	March 2012	JH
10. Check methodological and data changes resulting in recalculations	okay	SE	03.11.11	JB
11. Undertake completeness checks	Completness check for Waste	SE	15.11.11	JB
	Completness check for Energy		11.10.11	JB

Continued on next page

12. Compare estimates to previous estimates	check of KCA previous/latest key categories	SE	15.01.12	FL
	plausibility checks of the CRF tables	SE	15.11.12	FL
	plausibility checks of the CRF tables	PM	26.11.11	PI
	check stationary Energy	NA	22.12.11	DEF
	check stationary Ind. Proc., Solvents	NA	22.12.11	CHS
	check Waste	NA	22.12.11	WOM
	check mobile Energy, Agriculture,	SE	15.11.11	FL
	check Ind. Proc.,/Synthetic gases	SE	15.11.12	FL/SK
	check Agriculture	SE	15.11.11	FL
	check LULUCF	SE	15.11.11	FL
13. Archiving activities	Internal Review of documents submitted in April 2010; All reklevant documents archived	PM/PMA	29.11.11	PI
14. Further activities	see Inventory Development Plan, minutes of meetings Inventory Core Group and Review Reports UNFCCC	SE, NA, PM,PMA	Jun-11-Mar 12	all
Country-specific activities	***Specific procedures***			
20. Where LIE uses Swiss-specific methods: If a change in the Swiss inventory occurs, check whether the change has to be adopted for LIE or not	clarification of comprehensive questions	PM/PMA	07.12.07	AG
20. Where LIE uses Swiss-specific methods: If a change in the Swiss inventory occurs, check whether the change has to be adopted for LIE or not	check: Energy (stationary)	NA	22.12.11	DEF
	check: Solvents	NA	22.12.11	CHS
	Clarification of comprehensive questions in different sectors with SE	PM/NA	18.02.12	PI
	two independent checks of Energy (mobile)	SE	03.01.12	MH, JH
	check Energy (mobile)	SE	03.01.12	MH
	check waste (waste water treatment plants NO2)	NA	08.12.12	SO
	check Agriculture	SE	Nov/Dec	FL
	check LULUCF	SE	08.12.11	FL
	verification that land-use changes between different categories of unmanaged do not account for the UNFCCCC inventory	SE	17.12.11	FL/JH
21. Where LIE uses Swiss-specific EF: Where changes in the Swiss EFoccur, check whether the changes are also adequate for LIE or not	Clarify the changes of Emission factors in Agriculture	SE	04.09.11	JB
	Clarify the changes of Emission factors in Solvent and other porduct use	SE	30.09.11	JB
	Clarify the changes of Emission factors and activity data in Industrial Processes	SE	24.08.11	JB
	check: Energy (stationary)	NA	22.12.11	DEF
	check: Solvents	NA	22.12.11	CHS
	check waste	NA	22.12.11	WOM
	check Energy (mobile)	SE	16.12.11	FL
	check Agriculture	SE	Nov/Dec	FL
	check LULUCF	SE	18.12.11	FL
22. Check correctness of KCA, comparison with previous results	Plausibility checks of KCA	PM	16.11.12	PI
	cross-check within KCA with/without LULUCF 1990 and 2008: Emissions correct, thresholds correct. Comparison with KCA of Submission Apr 2009	NA	20.12.11	FL
23. Check correctness of uncertainty analysis, comparison with previous results	EBP-internal plausibility checks	NA	21.12.11	DEF
	Acontec internal plausibility checks	SE	Dec 2011	JB
24. Check of transcription errors CRF -> NIR (numbers, tables, figures)	INFRAS internal plausibility checks	NA	Dec 2011	JH
	EBP-internal control: Comparison of data in CRF tables with NIR	NA	22.12.11	DEF, CHS, WOM, SO
	INFRAS-internal control. Comparison of data in CRF tables and NIR. For the transcription of emission data into chapters Exec. Summ., 2. Trends, X.1 Overview (in all sectors), Energy, Agriculture, a INFRAS collaborator generates figures and tables, copies them into NIR and adjusts the text correspondingly. These working steps are afterwards checked by another collaborator of INFRAS.	NA NIC	10.1.12 11.1.12	FL/JH/ MH
25. Check for complete and correct references in NIR	EBP-internal checks	NA	22.12.11	DEF, CHS, WOM, SO
	INFRAS-internal checks	NA	09.01.12	MH
26. Check for correctness, completeness, transparency and quality of NIR	clarification of comprehensive questions	SE	Jan. 2012	JB
	final proofread Executive Summary, feedback to PI	NFP	March 2012	HK
	final proofread inventory/NIR, feedback and discussion with PI	QM	March 2012	AG
	final proofread inventory/NIR, discussion with JH, FL and JB	PM	March 2012	PI
	final proofread inventory/NIR, feedback to PI	PMA	March 2012	SB
	final proofread inventory/NIR, feedback to PI	SC	March 2012	HE
	Internal OEP discussions on the inventory/NIR draft with AG,SB, HE and PI	PM/PMA	March 2012	PI
	Feedback from OEP internal discusions	PM/PMA	March 2012	PI
	Final proofreading inventory/NIR	PM/PMA	March 2012	PI
	checked/adapted the correct quotation of LIE statistics for agricultural data (different years, also internal sources)	SE	02.02.12	FL
	unification of terms in the LULUCF chapter, i.e. the altitude categories or the term combination (combined) categories CC	SE	03.02.12	FL
27. Check for completeness of submission documents	Final check and Submission	PM/NIC NFP	foreseen 15.04.2012	HK/PI
28. Further activities	Archiving: INFRAS, EBP, save internally all data individually. NIR in MS-DOC and PDF format are sent to OEP. All tables in MS-EXCEL format are sent to OEP for separate archiving.	NA	foreseen April 2012	JH, FL DEF, CHS, WOM, SO
	Archiving: Save an backup all internally Data		01.04.12	JB

A8.2 Checklists for QA activities (internal review)

Liechtenstein's National Inventory Report
Review-Formular für das Interne Review Submission April 2012

Reviewer	**Patrick Insinna, Project Manager (PM); National Inventory Compiler (NIC),**
Amt / Firma	AFU
Telefon, E-Mail	00423 236 61 96
Begutachtete(s) Kapitel inklusive Annex, References	

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Kommentare des Reviewers (gelb) und Erwiderung der Autorin/des Autors (grün)
Executive Summary/ES 1.1: Bezugsjahr zu prognostizierten Temperaturen ist nicht klar.
done
Executive Summary/ES 1.2: Problem mit der Einwohnerzahl - welches sich durch die verschiedenen Kapitel zieht - nicht verständlich erläutert (siehe Kommentar in Kap 1.2.1. Bitte um interne Erklärung.
done, discussed with Patrick Insinna
Introduction/ Kap. 1.1.1: Absatz mit Permafrost umformulieren
Done
Kap. 2-10: Einzelne Richtigstellungen bzw. Formulierungs- und Darstellungsvorschläge
Done
Kap. 2-10/Annex: Einzelne Fragen/Änderungen zu Jahreszahlen, Berechnungen und Gewichtungen
Done
Kap. 13.4: Anpassungen evtl nötig, je nach Ergebnis des ARR 2011.
ARR not yet available

Review durchgeführt Datum / Signum	PI, 1.3.2012

Review zur Kenntnis genommen	
Datum / Signum	MH, 12.3.2012

Liechtenstein's National Inventory Report
Review-Formular für das Interne Review Submission März 2012

Reviewer	**Helmut Kindle**
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Begutachtete(s) Kapitel inklusive Annex, References	Executive summary

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Kommentare des Reviewers (gelb) und Erwiderung der Autorin/des Autors (grün)	
Einige redaktionelle Anmerkungen und eine Bemerkung zur Figure 1-3	
Comments taken into account.	
Review durchgeführt Datum / Signum	2.2.2012; Helmut Kindle

Review zur Kenntnis genommen	
Datum / Signum	07.03.2012, MH

Liechtenstein's National Inventory Report
Review-Formular für das Interne Review Submission März 2012

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Begutachtete(s) Kapitel inklusive Annex, References	Executive Summary, Part 1 and 2, Annex 8

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Kommentare des Reviewers (gelb) und Erwiderung der Autorin/des Autors (grün)	
ES. 1.2: Ergänzen der Auflistung um die Submission 2011.	
done	
Part 1.1.1, page 22/23: Quelle bei Energyconcept und Energy Efficiency Act korrigieren, d.h. statt OEP lautet die Quelle OEA. Anpassung Energy-Vision zu Energyconcept.	
done	
Annex 8: QA/QC Tabellen sind noch zu aktualisieren.	
done	
Review durchgeführt Datum / Signum	8. Februar 2012, Andreas Gstöhl

Review zur Kenntnis genommen	
Datum / Signum	07.03.2012, MH

Liechtenstein's National Inventory Report
Review-Formular für das Interne Review Submission März 2012

Reviewer	**Sven Braden**
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Begutachtete(s) Kapitel inklusive Annex, References	Executive summary, Chapter 13 Accounting on Kyoto Units

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Kommentare des Reviewers (gelb) und Erwiderung der Autorin/des Autors (grün)
Keine Kommentare und Anmerkungen
-

Review durchgeführt	
Datum / Signum	10.02.2012; Sven Braden

Review zur Kenntnis genommen	
Datum / Signum	07.03.2012, MH

Liechtenstein's National Inventory Report
Review-Formular für das Interne Review Submission März 2012

Reviewer	**Hanspeter Eberle**
Amt / Firma	Amt für Umweltschutz
Telefon, E-Mail	4232366193
Begutachtete(s) Kapitel inklusive Annex, References	7

NIR-AutorIn	Jürg Heldstab
Firma	INFRAS
Telefon, E-mail	+41 44 205 95 11, juerg.heldstab@infras.ch

Kommentare des Reviewers (gelb) und Erwiderung der Autorin/des Autors (grün)
Die Abbildung 7.4 war für mich nur schwer verständlich resp. sie ist sehr hypothetisch. '- zum Kommentar auf S. 53 habe ich meinen Komentar hinzugefügt.
No changes made to figure 7-4. Comments and proposals made on page 53 are taken into account.

Review durchgeführt	
Datum / Signum	15.02.2012, Hanspeter Eberle

Review zur Kenntnis genommen	
Datum / Signum	07.03.2012, MH

Liechtenstein's National Inventory Report
Review-Formular für das Interne Review Submission März 2012

Reviewer	**Jürgen Beckbissinger**
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Telefon, E-Mail	00423 230 07 88
Begutachtete(s) Kapitel inklusive Annex, References	Agriculture

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Telefon, E-mail	+41 44 205 95 11, juerg.heldstab@infras.ch

Kommentare des Reviewers (gelb) und Erwiderung der Autorin/des Autors (grün)	
Several inputs made concerning the major recalculation in agriculture, final results of the recalculation reviewed	
ok	
Review durchgeführt	
Datum / Signum	19.3.2012 / Bb

Review zur Kenntnis genommen	
Datum / Signum	20.3.2012 /fl

Table A - 15 Checklists for QA activity internal review.

A8.3 IDP Inventory development plan

The Inventory Development Plan (IDP) is a tool within Liechtenstein's National Inventory System (NIS) to improve the Greenhouse Gas Inventory and the National Inventory Report (NIR). It is updated regularly based on the recommendations of the expert review teams of the UNFCCC (ERT). The last three recommendations are FCCC/ARR/2006/LIE, FCCC/ARR/2008/LIE, FCCC/ARR/2009/LIE and FCCC/ARR/2010/LIE resulting from the Centralized Reviews in 2007, 2009 and 2010. The most recent recommendations from September 2011 are not yet available yet and therefore not (fully) included.

In the IDP the recommendations and planned improvements are summarized in a table. The meaning of the headers are shown on this page.

Responsibilities

Initial	Name	Insititution
HK	Helmut Kindle	Office of Environmental Protection (OEP)
AG	Andreas Gstohehl	Office of Environmental Protection (OEP)
PI	Patrick Insinna	Office of Environmental Protection (OEP)
HE	Hanspeter Eberle	Office of Environmental Protection (OEP)
SB	Sven Braden	Office of Environmental Protection (OEP)
JB	Jürgen Beckbissinger	Acontec, Schaan
DEF	Denise Fussen	Ernst Basler + Partner
CHS	Christina Seyler	Ernst Basler + Partner
JH	Jürg Heldstab	INFRAS
SO	Markus Sommerhalder	Ernst Basler + Partner

Priority

Level	Meaning
high	assigned to all key recommendations as listed in the Annual Inventory Review Reports (ARR)
medium	
low	

Status

Abbr.	Meaning
Finished	Work finished
Progress	Work in progress
Not yet	Work not yet started
To be checked	Recommendation is being checked

Reference

The last column in the IDP "Reference" refers to the relevant paragraph in the report of the individual review of the greenhouse gas inventory of Liechtenstein of the corresponding year (e.g. 2010_58 translates into paragraph 58 of the report on the inventory submitted in 2010, FCCC/ARR/2010/LIE.

Cross-cutting issues / Miscellaneous

No	Planned improvement	Deadline	Responsibility	Priority	Workload	Status	Reference
1	**Completeness**: CRF tables are completely filled with notation keys where appropriate. However, Liechtenstein did not complete table 7 for the years 1990–2003 and table 8 (b) for 1990–2005	ongoing	PI	high	mean	progress	2008_10
2	The **transparency** of Liechtenstein's submission could be improved further by the inclusion of additional information, especially for the categories to which Swiss country-specific methodologies and/or EFs have been applied.	ongoing	JH	mean	mean	progress	2008_11
4	The IPCC good practice guidance provides a tier 2 uncertainty analysis based on a **key category analysis**. The ERT noted that Liechtenstein's uncertainty for both activity data (AD) and EFs are given only at an aggregated level, which does not facilitate a tier 2 key category analysis.		PI/JH	low	high	Not to do in 2012	2008_16
6	**Follow-up to previous reviews** However, the ERT feels that the recommendation of the previous review to improve transparency in the energy and LULUCF sectors has not yet been fully addressed, and therefore the ERT reiterate the previous recommendation	ongoing	JH/CHS/DEF/SO	mean	high	progress	2008_19

Sector Energy

No	Planned improvement	Deadline	Responsibility	Priority	Workload	Status	Reference
13	Emissions from machinery in construction and industry are currently reported as off-road vehicles and other machinery under other (mobile 1.A.5b), which is not in line with the Revised 1996 IPCC Guidelines. The ERT recommends that Liechtenstein report these emissions under other (manufacturing industries and construction (1.2.Af) in its next annual inventory submission	Subm 2011	JH/JB	low	low	not yet accomplished	2009_44

Sectors Industrial processes and solvent and other product use

No	Planned improvement	Deadline	Responsibility	Priority	Workload	Status	Reference
-	No planned improvement						

Sector Agriculture

No	Planned improvement	Deadline	Responsibility	Priority	Workload	Status	Reference
-	No planned improvement						

Sector LULUCF

No	Planned improvement	Deadline	Responsibility	Priority	Workload	Status	Reference
22	The ERT recommends Liechtenstein report organic matter above mineral soil for dead organic matter, develop and implement QA/QC procedures and quantify the uncertainties of the key categories in its future annual submissions.		PI/JH	mean	mean	Progress made, QA/QC improvedwith double-checks.	2008_62
23	The attribution of a conversion period of 1–12 years for land converted to forest land is inconsistent with the IPCC good practice guidance for LULUCF, which defines the default land-use conversion period as 20 years or longer. Liechtenstein's current attribution of the conversion period tends to overestimate CO2 removals for forest land remaining forest land while underestimating CO2 removals for lands converted to forest land. The ERT recommends that Liechtenstein explore further whether the available historical data would support the use of a minimum of 20 years as the conversion period to distinguish the subcategories under forest land		PI/FL/JB	mean	mean	First estimation of Acontec from 23.11.2011 shows that the influence is negligible. Feasability is furhter checked	2008_65, 2009_68
26	The annual increase in living biomass was estimated and reported. Carbon stock changes due to land being converted to forest land were conservatively assumed to be zero for all carbon pools. Due to the attribution of a conversion period of 1–12 years for land converted to forest land, the AD for land converted to forest land were underestimated. As a result of these assumptions, CO2 removals for this category tend to be underestimated, while CO2 removals for forest land remaining forest land tend to be overestimated. The ERT recommends that Liechtenstein explore further whether the available historical data would support the use of a minimum of 20 years as the conversion period to distinguish the subcategories under forest land		FL/JB	mean	mean	see point 23	2008_69

Sector Waste

No	Planned improvement	Deadline	Responsibility	Priority	Workload	Status	Reference
27	**Waste water handling**: Liechtenstein used the IPCC default method to estimate N2O emissions from wastewater handling for human sewage. In the calculation, 36 kg/person/year is used as the protein consumption for all time series. The ERT encourages Liechtenstein to use year-specific values for improving accuracy in its future annual submission.	Sub 2011	SO/JB	low	low	Finished, year-specific values are used. No LIE specific data, CH data available	2008_79, 2009_85
28	There is no waste incineration plant in Liechtenstein and municipal waste is exported to Switzerland. Hence, Liechtenstein reported only emissions from illegal waste incineration using country-specific AD and CORINAIR EFs. According to assumptions for the waste composition of illegal waste in Switzerland (NIR CH), Liechtenstein assumed that 40 per cent of waste incinerated is non-biogenic. With regard to related EF it is recommended to revise following points: In previous submissions, the emission factor of fossil CO2 has been calculated by multiplying the corresponding Swiss EF by the factor 0.4. It will be verified whether this is plausible or should be corrected elsewise. Furthermore it will be checked whether it is justified to use a different emission factor for N2O than in the Swiss NIR.	Subm 2012	JB	high	low	In progres	2008_80
29	Waste Water handling: CH4 leakage of Biogas is estimated to be 0.2% of biogas generated. Latest data used in the Swiss NIR indicate a leakage of 0.75%. Recalculation of CH4 emissions.	Subm 2011	JB	low	low	Finished. New EF used and recalculation conducted.	ARR 2008_80
30	Composting: Liechtenstein reported CH4 and N2O emissions from composting. The amount of composting in small compost sites was estimated as a proportion of the amount of composting in centralized compost plants; this estimate was based on expert judgement. The proportion is 8 per cent in 1990 and 5 per cent in 2005. The ERT encourages Liechtenstein to provide more detailed information on the expert judgement in its future inventory submission.		AG/JB	mean	mean	Finisched	2008_81, 2009_87
31	The ERT recommends that Liechtenstein reports CO2 emissions for biogenic and non-biogenic (fossil) CO2 separately. During the review, Lichtenstein informed the ERT that the recommendation will be implemented in the 2012 submission.	Subm 2012	JB	High	Low	Finished	2008_80

Done for Submission 2012

7 (Energy)	The ERT recommends that Liechtenstein implement QA/QC activities for AD in the energy sector.	ongoing	AG	mean	high	Finished, no further improvement due to technical limitations	
17a (Industrial Processes	CRF table 2(II)s2 provides the 'Potential/Actual emissions ratio' for total HFCs and PFCs, even though Liechtenstein does not report potential emissions for these gases.	Subm 2011	JB/SK			Finished. Explanation added in Chpt 4.7.3	S&A II, cell E8
13a (Energy)	CO_2 emissions from fuel combustion were calculated using the reference approach and the sectoral approach. For the year 2008, there is a difference of 0.04% in the CO_2 emission estimates between the reference approach and the sectoral approach. Explanations are not provided in the documentation box of table 1.A(c) of the CRF. In addition, the NIR provides explanations for the fluctuations in the differences between the two approaches over the years.	Subm 2011	JB			Finished	S&A II, cell F8
18 (Agriculture)	Enteric fermentation: The EFs that are used are a mixture of IPCC default factors and Swiss country-specific factors. The ERT recommends that Liechtenstein provide an explanation, reflecting its national situation, on the applicability of Swiss country-specific methods and factors. (Party: Switzerland has recalculated the emission time series due to several corrections. Liechtenstein will check the implications for the emission modelling of Sector Agriculture before submission 2011)	ongoing	FL/JB	mean	high	Finished, see Recalculations in Chpt. 6 of the NIR	2008_50
19 (Agriculture)	Manure Management/direct soil emissions/indirect soil emissions: The ERT also recommends that Liechtenstein develop country-specific factors in order to reflect its national situation and agricultural practices.	---	FL/JB	low	high	LIE has improved reporting, inculded LIE specific data wherever available (milk statistics, non-applicability of savannah) and for the rest, the Swiss model and factors are applied in a consistent way. There is no reason why LIE factors should be significantly different to LIE factors due to the similarity of agricultural practices and structure. See also Explanations in Chpt. 6 of the NIR	2008_52, 2008_53, 2008_55, 2008_56
20 (Agriculture)	The ERT reiterates the finding from the previous review report that the NIR is not sufficiently transparent and has not been improved with respect to the previous submission. In addition, the ERT noted that the recommendation from the previous review report that Liechtenstein provide in the NIR proper justification for the applicability of Swiss country-specific methodologies and EFs to its national circumstances has not been yet implemented. This includes statistics on annual milk production per dairy cow, average nitrogen excretion rates, mineral fertilizer consumption, annual ammonia emission, and nitrogen leaching. Furthermore, no justification has been provided for the reported non-applicability of savanna burning, even though the ERT considers that this activity may not occur in the country (Party: Switzerland has recalculated the emission time series due to several corrections. Liechtenstein will check the implications for the emission modelling of Sector Agriculture before submission 2011 and will also improve the reporting in the NIR)		FL/JB	mean	high		2009_56

Done for Submission 2012 (cont.)

20a (Agricultur e)	As raised in previous SA report, Liechtenstein reports all fraction used to estimate N2O emissions as not estimated.		JB/FL	High	High	Finished, see above	S&A II, cell E10, ARR 2010_58
20b (Agricultur e)	“Breeding cattle” should be reported in the CRF tables of the next submission under the relevant cattle group an not under “other”		JB/FL	Mean	Mean	Finished, see above	2009_58
20c (Agricultur e)	The distribution of N to the different AWMS has to be improved/recalculated	NIR 2012	JB/FL	High	HIgh	Finished, see above	ARR 2010_59&60 &61
25 (LULUCF)	The tier 2 approach in the IPCC good practice guidance for LULUCF, Swiss methods and country-specific EFs were used for estimating CO2 emissions from cultivated organic soil for grassland remaining grassland and for carbon stock change for land converted to grassland. Carbon stock changes in living biomass, dead organic matter and mineral soils are assumed to be zero for grassland remaining grassland. CO2 emissions from cultivated organic soil for grassland remaining grassland were incorrectly reported for mineral soils. The ERT recommends that Liechtenstein improve the estimate and report of carbon stock changes in soils for this category in its future annual submission. During the review, Lichtenstein informed the ERT that reporting will be checked and corrected in the 2010 submission.	Subm 2011	PI/JH	mean	mean	Finished: Swiss methods and carbon contents (EF) are used with LIE specific AD. Changes in living biomass, dead org. matter and mine are estimated and not zero for grassland remaining grassland. Changes in soil are all reported under mineral soils as no differentiation can be Finished between mineral and organic soils.	2008_67

Annex 9: Voluntary Supplementary Information for Article 3 paragraph 3 of the Kyoto Protocol: Kyoto Tables

No supplementary information in addition to Chapter 11

Annex 10: Information required under Art. 7 paragraph 2 of the Kyoto Protocol: National Registry and Commitment Period Reserve (CPR)

A10.1 Introduction

Under the terms of Art. 7 of the Kyoto Protocol, each Party included in Annex I shall provide the necessary supplementary information in its National Inventory Report (NIR) to demonstrate compliance with Art. 3 of the Kyoto Protocol. Decision 15/CMP.1 is – inter alia – focusing on the reporting requirements for changes in the national registries. Additionally decision 15/CMP.1 refer to Art. 5, para 1, defining the national Guidelines for national systems. Each Party shall describe the changes that have occurred in the system as well as in the registry, compared with the information reported in its last submission. The changes described are in comparison with the NIR submitted in April 2011.

A10.2 Changes in the National System

The national inventory system remains unchanged compared to the description given in the Initial Report under the Kyoto submitted in December 2006 (OEP 2006a, 2007b).

A10.3 Registry administrator

The name and contact information of the registry administrator designated by the Party to maintain the national registry:

No changes compared to previous submission (2011).

Registry Administrator	**Contacts**
Office of Environmental Protection (OEP)	Main Contact
P.O. Box 684	Patrick Insinna
Dr. Grass-Strasse 12	Email: patrick.insinna@aus.llv.li
9490 Vaduz	
Principality of Liechtenstein	Alternative Contact 1
	Andreas Gstoehl
phone: +423 236 75 96	Email: andreas.gstoehl@aus.llv.li
fax: +423 236 61 99	
email: registry@aus.llv.li	Alternative Contact 2
	Helmut Kindle
website: http://www.llv.li/amtsstellen/llv-aus-emissionshandel_en.htm	Email: helmut.kindle@aus.llv.li

A10.4 Consolidated system

The names of the other Parties with which the Party cooperates by maintaining the national registries in a consolidated system:

No changes compared to IR 2006. Liechtenstein still cooperates with Switzerland and Monaco for the setting-up and operation of the IT-Platform (hardware and software) for the National Registry. Switzerland is responsible for the technical hosting of the registries of these Parties on servers physically located in Switzerland. The three National Registries are maintained as independent systems with independent registry administrators. The National Registry is based on the Seringas™ registry software, which was developed by the French Caisse des Dépôts et Consignations, CDC. Further developments, updates and releases of the software are undertaken in cooperation with all Seringas™ licensees.

A10.5 Database structure and capacity

Description of the database structure and capacity of the national registry:

No changes compared to submission 2011. According to Decision 13/CMP.1, paragraph 18 „any two or more Parties may voluntarily maintain their respective national registries in a consolidated system, provided that each national registry remains distinct“. This consolidated solution was implemented by Liechtenstein together with Monaco and Switzerland. The latter acting as the technical host with servers physically located in the Swiss Federal Office of Information Technology, Systems and Telecommunication (FOITT). The three Parties' registries are running in parallel but maintained as independent systems with independent registry administrators. The Information and Communication Technology (ICT) architecture is illustrated in Fig. A-1.

French software application SERINGAS from the developer „Caisse des Depôts et Consingnations (CDC) has been implemented using a Microsoft SQL Server relational data base management system with a dedicated conceptual data model developed by CDC (Fig. A-2).

The total capacity of the registry is only limited by the maximum size of the Microsoft SQL Server. By Dezember 2011 410 accounts – 2 operator and 408 personal holding accounts - have been created. Currently (End of 2011) 25 Party Holding accounts, 2 operator and 48 personal holding accounts are active.

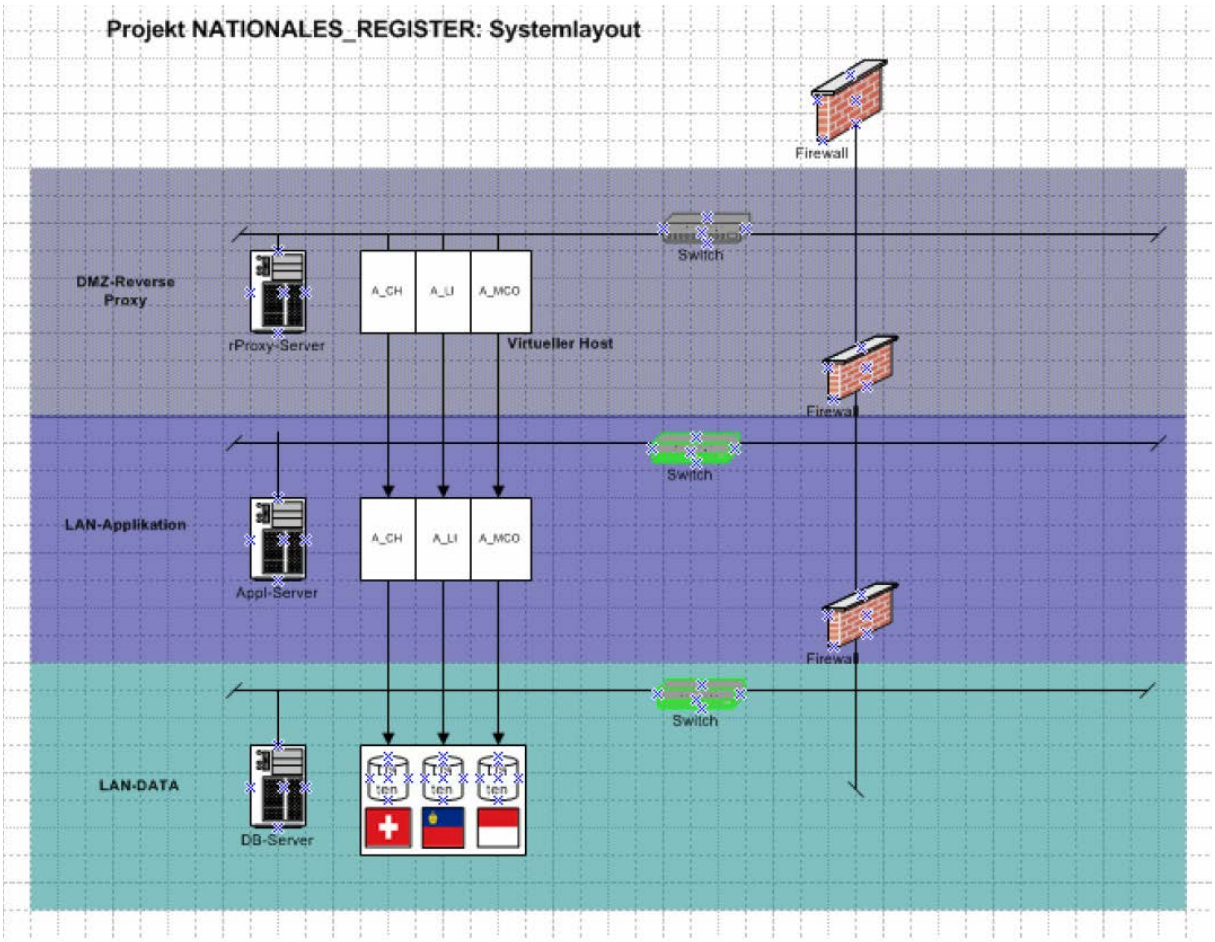

Figure A - 1 Information and communication technology (ICT) architecture for the consolidated registry system of Switzerland, Liechtenstein and Monaco. ES Figure kindly provided by the Federal Office of Information Technology, Systems and Telecommunication (FOITT).

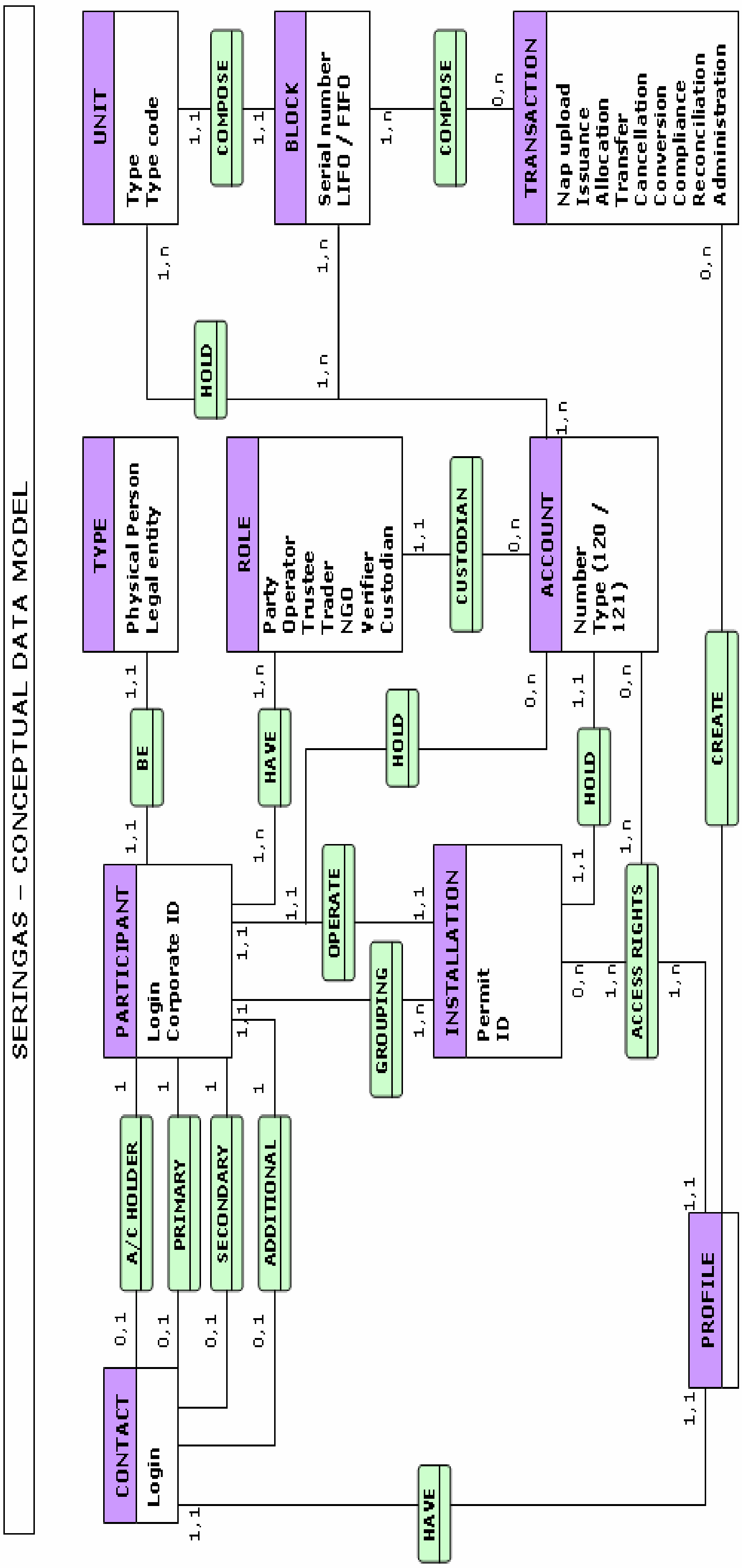

Figure A - 2 Conceptual Data Model developed by CDC. Figure taken from the „Registry Administrator User Guide Version 4“, page 19.

A10.6 Conformity with Data Exchange Standards (DES)

Description of how the national registry conforms to the technical standards for data exchange between registry systems for the purpose of ensuring the accurate, transparent and efficient exchange of data between national registries, the clean development mechanism registry and the transaction log (decision 19/CP.7):

No changes compared to submission 2011. Liechtenstein's National Registry is in conformity with the DES in the relevant version to ensure the correct treatment and reception of information by the ITL. Software version 4.2.1 of SERINGAS which were approved by the International Transaction Log (ITL) on 5. September 2007 through interoperability tests according to Annex H of the DES, version 1.1.002, is still used. With the final Independent Assessment Report (IAR) dating from 7. December, the ITL Administrator confirmed the successfully completed initialization process.

Further, the requirements mentioned in IR 2006 concerning account numbers, serial numbers of units including project identifier and transaction numbers (Annex F) as well as concerning the list and electronic format of information transmitted electronically when transferring, acquiring, issuing, cancelling or retiring AAUs, CERs, ERUs or RMUs to other national registries or to the CDM registry and/or the ITL (Annex I) are still fulfilled.

A10.7 Prevention of discrepancies

Description of the procedures employed in the national registry to minimize discrepancies in the issuance, transfer, acquisition, cancellation and retirement of ERUs, CERs, tCERs, lCERs, AAUs and/or RMUs, and replacement of tCERs and lCERs, and of the steps taken to terminate transactions where a discrepancy is notified and to correct problems in the event of a failure to terminate the transactions:

No changes compared to submission 2011. To prevent discrepancies between national registries and the ITL, the SERINGAS Software applies a number of internal checks before submitting transactions to the ITL.

General checks	Equivalent check in ITL/CITL
Transaction identifier check: Transactions identifier proposed by the registry must be unique. Transaction identifier received by the registry must be unique.	3001 **and more***
Transaction status check: Completed, terminated, accepted, rejected or cancelled status are final status, thus, once a transaction has completed, terminated, accepted, rejected or cancelled status, it can not change its status anymore	3003, 3004, 3007, 3008, 3009, 3013, 3014, 3015, 3016

Transaction status evolution check: The registry propose a transaction with status = “proposed” If the transaction status comes back with “checked with discrepancies”, then the registry terminate the transaction If the transaction status comes back with “checked with no discrepancies”, then the registry complete the transaction	3005, 3006, 3011
Unit check: a unit is compulsory to create a transaction, and only one unit per transaction (except for cancellation and replacement transaction)	5004, 5057
The source account check: all transactions must have an active source account (except for Issuance transaction). The source account for a transaction can only be from type 100, 120 and 121. More restrictions can be added, depending on the transaction type. Only one account can be selected	4011, 4012, 4014, 7406 **and more**
The destination account check: all transactions must have an active destination account; only one account destination can be selected.	5154, 7208, 5204, 5253 **and more**
Quantity check: The quantity of a transaction must not by greater than the quantity of the source account (except for issuance transaction as it has no source account). The quantity of a transaction must be greater than 0	4016 **and more**
Period check: the applicable period of the unit is compulsory to create a transaction, and only one can be selected (except for issuance, the period is calculated by the system)	**No equivalent**
Unit blocks check: the unit block of a transaction is flagged as “reserved” until the transaction has a final status (Completed, terminated, accepted, rejected or cancelled)**.** A block flagged as “reserved” can not be used for another transaction.	4010
The destination registry check: for all transactions, the destination registry is the same as the source registry, except for external transfers and excess issuance cancellation transactions.	4006
Project checks: project is compulsory for transactions involving ERU, CER, tCER and lCER.	**No equivalent**

* **“<ITL/CITL code> and more”** means that the registry makes the same checks as the ITL/CITL which provide for that reason with a particular <ITL/CITL code>, but this code does not cover all checks made by the registry, thus, there’s no right equivalent in the CITL/ITL codes for the appropriate registry checks.

Specific transaction checks Issuance Transaction (01-00)	Equivalent check in ITL/CITL
Issuance unit check: only AAU and RMU can be issued by the registry	5001, 5002, 5003
Issuance period check: The applicable and the commitment period are calculated from the system date: if the system date is in 2008 to 2012, then the applicable and the commitment period is 1. if the system date in 2013 to 2017, the then the applicable and the commitment period is 2	5005, 5006, **and more**
Issuance of serial number check: The serial number must be unique, can not have the same serial number for AAU and RMU	5007, **and more**
Issuance acquiring account check: the issuance acquiring account must be 100-2-0	5017, **and more**
Issuance LULUCF activity check: the LULUCF activity is compulsory when the registry issue RMU	**No equivalent**

Specific transaction checks Issuance of allowances (10-52)	Equivalent check in ITL/CITL
Issuance of allowances unit check: only AAU can be choose for this transaction, as the issuance of allowances is treated as a conversion of AAU into EUA	7205, 7219 **and more**
Issuance of allowances period check: the period of the allowances is the same period as the AAU used for the issuance	7205
Issuance of allowances serial number check: The serial number must be the same as the AAU used for the issuance	**No equivalent**
Issuance of allowance source account checks: the source account must be 100-2-0	**No equivalent**
Issuance of allowance destination account checks: the destination account must be 100-4-0	7202 **and more**

Specific transaction checks Allocation transaction (10-53)	Equivalent check in ITL/CITL
Allocation units check: only allowances (EUA) can be used for allocation	No equivalent
Allocation source account check: the source account is 100-4-0	7360, **and more**
Allocation destination account check: the destination account must be account type 120	7206
Allocation year check: the allocation year is compulsory	**No equivalent**

Specific transaction checks Correction to allowances (10-55)	Equivalent check in ITL/CITL
Correction to allowances unit check: only allowances (EUA) can be used a correction to allowances transaction	**No equivalent**
Correction to allowances source account check: the source account is 100-4-0	**No equivalent**
Correction to allowances destination account check: the source account is 100-2-0	**No equivalent**

Specific transaction checks Voluntary cancellation (04-00)	Equivalent check in ITL/CITL
Voluntary cancellation unit check: all Kyoto units and EUA are useable for voluntary cancellation.	**No equivalent**
Voluntary cancellation source account check: only holding accounts can be used as source account for cancellation, with the exception of 100-3-0	**No equivalent**
Voluntary cancellation destination account check: only account type 230 is allowed as destination account for voluntary cancellation transactions.	5153 **and more**

Specific transaction checks Domestic transfers (10-00)	Equivalent check in ITL/CITL
Domestic transfer unit check: all Kyoto units and EUA are useable for domestic transfers	**No equivalent**
Domestic transfer destination account check: the destination account can only be holding accounts (type 100, 120 or 121) except 100-4-0; only one destination account can be entered.	7407

Specific transaction checks External transfers, outgoing (03-00)	Equivalent check in ITL/CITL
External transfers, outgoing unit check: all Kyoto units and EUA are useable for outgoing external transfers	**No equivalent**
External transfer, outgoing destination account check: the destination account can only be holding accounts (type 100, 120 or 121); only one destination account can be entered.	**No equivalent**
Domestic transfer, outgoing destination registry check: the destination registry can not be source registry.	4007

Specific transaction checks **External transfers, incoming (03-00)**	**Equivalent check in ITL/CITL**
External transfers, incoming unit check: all Kyoto units and EUA are useable for incoming external transfers	**No equivalent**
External transfer, incoming destination account check: the destination account can only be holding accounts (type 100, 120 or 121), and the account number must exists in the acquiring registry.	**No equivalent**

Specific transaction checks **Conversion of AAU and RMU into ERU (02-00)**	**Equivalent check in ITL/CITL**
Conversion units check: only AAU and RMU can be used for a conversion transaction	5056
Conversion source account check: the source account can only be national holding accounts (type 100).	5052
Conversion destination account check: the destination account is the same as the source account	**No equivalent**
Conversion project check: a project is compulsory for a conversion transaction. The project has to be created before the conversion transaction.	**No equivalent**

Specific transaction checks **Surrendering (10-02)**	**Equivalent check in ITL/CITL**
Surrendering units check: only EUA, CER and ERU converted from AAU can be used for a surrendering transaction	7356
Surrendering source account check: the source account can only be operator holding accounts (type 120).	7354
Surrendering destination account check: the destination account has to be 100-3-0	7202
Surrendering year check: the surrendering year is compulsory	**No equivalent**

Specific transaction checks **Cancellation and replacement (10-41)**	**Equivalent check in ITL/CITL**
Cancellation and replacement destination account check: the destination account can only be a national holding account (type 100)	7202, 7407
Cancellation and replacement transaction date check: Cancellation and replacement transaction can only be made on the 1st of May	**No equivalent**
Cancellation and replacement quantity check: the quantity replaced is calculated with the percentage entered in the settings of the transaction. The quantity “cancelled” is all EUA of holding accounts except 100-3-0	**No equivalent**
Cancellation and replacement transaction procedure: move all EUA of the previous period from holding accounts, by transferring them into a national holding account and converting them into AAU (“cancellation” process), then convert AAU (from the account 100-8-0) of the current period into EUA and transfers the EUA from the current period to the holding accounts (“replacement”). The quantity is of the replacement is calculated from the percentage set for the transaction.	7205, 7219, 7360, 7402, 7406

Specific transaction checks **Retirement(05-00)**	**Equivalent check in ITL/CITL**
Retirement unit check: All Kyoto units can be used. Allowances (EUA) are not useable.	7365 **and more**
Retirement transaction date check: retirement transactions can be made only on the 30th of June	
Retirement source account check: the retirement source account can only be national holding account (type 100)	7360 **and more**
Retirement destination account check: the destination account can only be a retirement account (type 300)	5252

Notification Checks Net source cancellation (04-00)	Equivalent check in ITL/CITL
Net source cancellation notification Identifier check: the notification identifier is compulsory, and fixed by the notification	5158
Net source cancellation unit check: only AAU, RMU, CER, ERU and EUA can be used for a net source cancellation transaction.	5156
Voluntary cancellation destination account check: only account type 210 is allowed as destination account for voluntary cancellation transactions.	5153

Notification Checks Non compliance cancellation (04-00)	Equivalent check in ITL/CITL
Non compliance cancellation notification Identifier check: the notification identifier is compulsory, and fixed by the notification	5159
Net source cancellation unit check: only AAU, RMU, CER, ERU and EUA can be used for a net source cancellation transaction.	5156
Voluntary cancellation destination account check: only account type 220 is allowed as destination account for voluntary cancellation transactions.	5153

Notification Checks Expiry date replacement (06-00)	Equivalent check in ITL/CITL
Expiry date replacement notification Identifier check: the notification identifier is compulsory, and fixed by the notification	5216, 5217
Expiry date replacement unit check: only AAU, RMU, CER, tCER and EUA can be used for a replacement of tCER. Only AAU, RMU, CER can be used for a replacement of lCER. The unit to be replaced is given by the notification and is compulsory for this transaction. Once the unit is replaced, it is flagged as replaced.	5206, 5207, **and more**
Expiry date replacement destination account check: only account type 411 is allowed as destination account for replacement of tCER. Only account type 421 is allowed as destination account for replacement of lCER.	5202, 5203, 5213, 5214
Expiry date replacement quantity check: the quantity fixed by the notification and can not be changed.	5209

Notification Checks **Reversal of storage cancellation (04-00)**	**Equivalent check in ITL/CITL**
Reversal of storage cancellation notification Identifier check: the notification identifier is compulsory, and fixed by the notification	5160
Reversal of storage cancellation unit check: only lCER of the project described in the notification can be used for a reversal of storage cancellation transaction.	**No equivalent**
Reversal of storage cancellation destination account check: only account type 250 is allowed as destination account for this transaction.	5153

Notification Checks **Reversal of storage cancellation (06-00)**	**Equivalent check in ITL/CITL**
Reversal of storage replacement notification Identifier check: the notification identifier is compulsory, and fixed by the notification	5218, 5220
Reversal of storage replacement unit check: only AAU, RMU, ERU, CER, EUA and lCER of the project described in the notification can be used for a reversal of storage cancellation transaction. The unit to be replaced is lCER and is compulsory for this transaction. Once the unit is replaced, it is flagged as replaced.	5206, 5207, 5215
Reversal of storage replacement destination account check: only account type 422 is allowed as destination account for this transaction.	5203
Reversal of storage replacement quantity check: the quantity fixed by the notification and it can be changed. The quantity is the same for replacing units and replaced units.	5209

Notification Checks **Non submission of certification report cancellation (04-00)**	**Equivalent check in ITL/CITL**
Non submission of certification cancellation notification Identifier check: the notification identifier is compulsory, and fixed by the notification	5161
Non submission of certification cancellation unit check: only lCER of the project described in the notification can be used for a non submission of certification cancellation transaction.	**No equivalent**
Non submission of certification cancellation destination account check: only account type 250 is allowed as destination account for this transaction.	5153

Notification Checks **Non submission of certification report cancellation (06-00)**	**Equivalent check in ITL/CITL**
Non submission of certification replacement notification Identifier check: the notification identifier is compulsory, and fixed by the notification	5219, 5220
Non submission of certification replacement unit check: only AAU, RMU, ERU, CER, EUA and lCER of the project described in the notification can be used for a reversal of storage cancellation transaction. The unit to be replaced is lCER and is compulsory for this transaction. Once the unit is replaced, it is flagged as replaced.	5206, 5207
Non submission of certification replacement destination account check: only account type 423 is allowed as destination account for this transaction.	5203
Non submission of certification replacement quantity check: the quantity fixed by the notification and it can be changed. The quantity is the same for replacing units and replaced units.	5209

Notification Checks **Excess issuance for CDM project cancellation (03-00)**	**Equivalent check in ITL/CITL**
Excess issuance for CDM cancellation notification Identifier check: the notification identifier is compulsory, and fixed by the notification or received by mail	**No equivalent**
Excess issuance for CDM cancellation destination account check: only account type 240 is allowed as destination account for this transaction.	**No equivalent**
Excess issuance for CDM cancellation destination registry check: only CDM registry is allowed for this transaction	5152

Notification Checks **Carry-over (07-00)**	**Equivalent check in ITL/CITL**
Carry-over notification Identifier check: the notification identifier is compulsory, and fixed by the notification.	5310
Carry-over unit check: only AAU, ERU converted from AAU and CER can be carried over. The commitment period is increased by one period.	5303, 5305, 5306, 5307
Carry-over source account check: only holding account type can be used for the carry-over transaction.	5302
Carry-over destination account check: the destination account must be the same as the source account.	**No equivalent**

Notification Checks Expiry date change (08-00)	Equivalent check in ITL/CITL
Expiry date change notification Identifier check: the notification identifier is compulsory, and fixed by the notification.	5453
Expiry date change unit check: only unit fixed by the notification is used for the transaction.	5454

Table A - 16 List of internal checks; taken from the document “Seringas internal checks before submitting transactions to ITL”, 15. December 2008.

A10.8 Determent of unauthorized manipulations

An overview of security measures employed in the national registry to prevent unauthorized manipulations and to prevent operator error and of how these measures are kept up to date:

In 2011 one additional scurity measure has been implemented. The third account representative has been set to mandatory as of February 2011. This representative fulfils the function to confirm transactions initiated by the first and second representative. This 4-eyes-priciple should restrain the possiblitiy of transactions done by unauthorized persons who have hacked or stolen access data from representatives.

The measures below did not change compared to submission 2011.

User identification and authentification

Every user of the registry system is identified by a distinctive Login name and authenticated by a personal password composed of a minimum of 10 characters including at least one number. The validity of the password is limited on 60 days and have to be renewed accordingly. The new password must be different from the last 10 password and must not contain neither the surname or name nor the login of the user. Plain text of the password can not be viewed by third persons or even the registry administrator as it is tored by 1-way coding.

Profile Management

Every user is designed to a determined profile depending on his/her role defined in the application form and implemented by the system administrator. Currently there are seven profiles available:

- P1 = System administrator (Registry administrator)
- P2 = Registry administrator
- P3 = Account consultant
- P4 = Primary authorized contact
- P5 = Secondary authorized contact
- P6 = Guest
- P7 = Verified allowances management (Verifier)

- P8 = Verified allowances validation (Competent authority)

Authorized functionalities for each profile are managed as shown in Table A - 17.

Access Protection

Apart from the measures within the software for the identification and authentication of authorised users, the following technical and organisational measures are in place, to prevent third parties access to the data:

- SSL-based encoding of the data transmission in the WEB and user authentication to gain entry to the system
- Employment of continuously updated virus-scanner software on the servers and the clients of the registry administration
- Continuous security updates of the system software
- Network infrastructure with hardware firewalls
- Continuous check of the firewall logs for attack attempts,

Authorised functionalities	**System administrator**	**Registry Administrator**	**Account consult**	**Primary authorized contact**	**Secondary**	**Guest**	**Verified allowances management (Verifier)**	**Verified allowances validation (Competent authority)**
Add account	x	x						
Add contact	x	x		x				
Add installation	x	x						
Add operation	x	x		x	x			
Add participant	x	x		x				
Add processing unit	x	x						
Add profile	x							
Add unit	x	x						
Advanced search	x	x	x	x	x	x	x	x
Advanced search to document text	x	x	x	x	x	x	x	x
Categories of activities management	x							
Change main participant	x	x						
Compliance status	x	x						
Consult account	x	x		x	x			
Consult contact	x	x	x	x	x			x
Consult installation	x	x	x	x	x			x
Consult NAP detail	x	x						
Consult NAP Table	x	x						

Consult transaction	x	x	x	x	x			
Consult participant	x	x	x	x	x		x	x
Consult processing unit	x	x		x	x			
Consult profile	x	x	x	x	x			
Consult unit	x	x		x				
Consult reports	x	x	x	x	x		x	x
Consult verified allowances	x	x	x	x			x	x
Create contact	x	x						
Create participant	x	x		x	x			
Create processing units	x	x		x	X			
Create installation	x	x						
Create account	x	X						
Create transaction	x	x		x	x			
Create unit	x	x						
Create profile	x	x						
Create verified allowances	x						x	
Disconnections	x	x	x	x	x			x
Delete account	x	x		x				
Delete contact	x	x		x				
Delete installation	x	x						
Delete participant	x	x		x				
Delete processing unit	x	x		x	x			
Delete profile	x	x						
Delete Transaction	x	x						
Delete unit	x	x						
Enter verified emissions	x	x					x	x
Installation load from xml file	x							
Modify account	x	x		x	x			
Modify contact	x	x		x	x			
Modify installation	x	x		x	x			
Modify participant	x	x		x	x			
Modify password	x	x	x	x	x		x	
Modify processing unit	x	x		x	x			
Modify profile	x							
Modify unit	x	x						
NAP load from xml file	X							
Operator load from xml file	X							
Password management	X	x		x	x			
Validate verified emissions	X	x						x

Table A - 17 Authorized functionalities for profiles.

A10.9 Public Reports

A list of the information publicly accessible by means of the user interface to the national registry:

No changes compared to submission 2011. For each account the following reports are available on the public area of the national registry:

1) List of legal entities holding an account in the national registry
2) List of installations in line with the European emissions trading directive
3) List of accounts opened in the national registry
4) Annual summary of quantity of units per type of operation performed in the national registry
5) Compliance status of installations concerning the declaration of verified emissions, grouped by operators
6) Summary statement on the quantity of allowances surrendered by an operator for compliance
7) Report on consolidated position of all installations verified emissions compared with total allowances surrendered
8) Report on the assessment of operator's compliance, grouped by operators
9) List of non-compliant installations
10) Verified emissions table

Additionally, FAQs, international texts (Kyoto Protocol, Marrakesh Accords etc.), and details of the national allocation plan are publicly available by means of the user interface.

A10.10 Internet address

No changes compared to submission 2011. The URL of the interface for the national registry of Liechtenstein is:

www.emissionshandelsregister.li and alias

www.emissionstradingregistry.li

A10.11 Safeguard and Recovery Plan

A description of measures taken to safeguard, maintain and recover data in order to ensure the integrity of data storage and the recovery of registry services in the event of a disaster:

No changes compared to submission 2011. The planned measures taken to safeguard, maintain and recover data in the event of a disaster first presented in the IR 2006 are now implemented:

	Description	Frequency	Retention Period	Storage
System data	Full Backup	Weekly	3 months	Tape, offsite
	Incremental backup	Daily	1 week	Tape, offsite
Application DB	Online backup of the data base on a daily basis	Daily	3 months	Tape, offsite
	Creating transaction logfiles	Hourly	1 week	Local system disk on the data base server. This device is separated from the device holding the DB.
Transaction Logfiles	Transaction logfiles will be subject to the system data backup			

Table A - 18 Backup strategy of National Registry (Source: Initial Report of Switzerland).

A10.12 Test procedures

The results of any test procedures that might be available or developed with the aim of testing the performance, procedures and security measures of the national registry undertaken pursuant to the provisions of decision 19/CP.7 relating to the technical standards for data exchange between registry systems:

No changes compared to submission 2011. Interoperability tests based on Annex H of the DES version 1.1.002 were performed on 5. September 2007 and passed successfully. Additionally, the Remote Tests between the national registry of Liechtenstein and the Community Independent Transaction Log (CITL) focusing on issues relevant for EU-ETS (Allocation Plan Details; Issuance of EUAs, etc) were carried in line with the ETS Testing Plan Version 4 out and completed successfully.

A10.13 Commitment period reserve (CPR)

No changes compared to submission 2011 (compare Chapter 12.5). According to the Annex of decision 11/CMP.1, each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90 per cent of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8, of the Kyoto Protocol, or 100 per cent of five times its most recently reviewed inventory, whichever is lowest.

In order to determine which of the two methods to calculate the commitment period reserve results in the lower value, the results of both methods are indicated inTable A - 19

Method 1		Method 2	
Assigned amount calculated pursuant to Art. 3, para. 7 and 8 of the Kyoto protocol (five times 92% of 1990 emissions), see OEP (2007b) [Gg CO2 equivalent]	1'055.623	2010 emissions without LULUCF, see Table 2-1, [Gg CO2 equivalent]	233.20
90% of the assigned amount [Gg CO2 equivalent]	950.061	100% of five times the 2010 emissions without LULUCF [Gg CO2 equivalent]	1166.00

Table A - 19 Calculation of Liechtenstein's commitment period reserve 2008.

The CPR remains unchanged since method 1 still results in the lower value and is therefore used to calculate the minimum amount of the CPR. **The commitment period reserve of Liechtenstein should therefore not drop below 950.061 Gg CO_2 equivalent (0.950061 million tonnes CO_2 equivalent).**